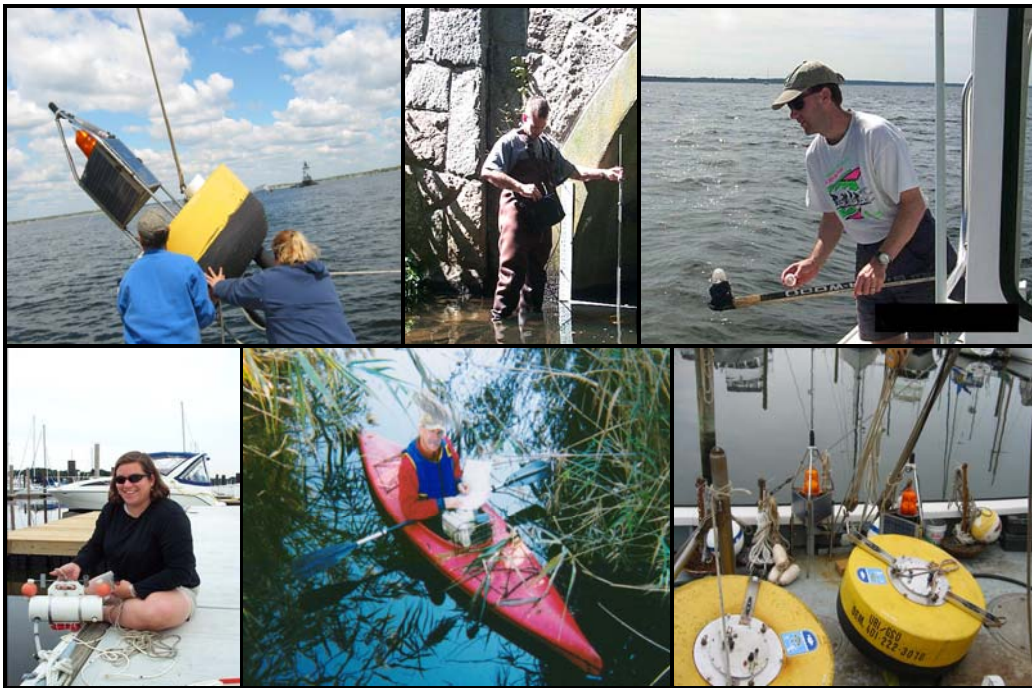


State of Rhode Island and Providence Plantations

Water Monitoring Strategy

2005-2010



September 30, 2005

DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OFFICE OF WATER RESOURCES

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Rhode Island Water Monitoring Strategy

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Executive Summary

Introduction and Purpose

Water monitoring is an essential component of Rhode Island's overall approach to protecting and restoring its vital water resources, including Narragansett Bay. This strategy describes the approach, sampling designs and related actions that are needed to implement an effective, comprehensive monitoring and assessment program for surface waters in the state. When fully implemented as proposed, it will provide data essential to state management programs in several agencies. It will also allow the Rhode Island Department of Environmental Management (DEM) to comprehensively assess water quality conditions with respect to supporting aquatic life and recreational uses of surface waters statewide over the next six years (by 2011). The addition of monitoring for fish tissue contamination will allow DEM to complete a comprehensive assessment of all designated uses of surface waters by 2014. It is a fundamental vision of this strategy that ambient monitoring and assessment will function to support all state water resource programs in addition to its traditional role of characterizing water quality conditions.

This strategy was designed to comply with EPA guidance and be responsive to new state legislation that mandated a comprehensive monitoring program be developed and implemented to support management and protection of Narragansett Bay and its watershed. It applies to all surface waters including coastal waters, rivers and streams and lakes and ponds. It reflects the activities of multiple agencies from government, academia and the non-profit sector. It will be revised over the next two years to incorporate strategies for groundwater, wetlands and sediments. The strategy is designed to support the following purposes:

- 1) conduct an inventory of all water resources;
- 2) determine ambient water quality conditions and assess trends in condition;
- 3) characterize the physical characteristics of surface waters; e.g. streamflows;
- 4) identify causes and sources of water quality problems including emerging water pollution problems;
- 5) identify threats to public health associated with water pollution;
- 6) develop and implement a variety of resource management programs aimed at protecting and restoring water quality; managing water quantities; including drought management; protecting and restoring aquatic and marine ecosystems, managing fisheries and protecting public health.
- 7) evaluate the effectiveness of water resource programs, including pollution control efforts;
- 8) respond to emergencies.

While acknowledging a large number of entities are involved in various monitoring activities, the strategy identifies the state as having the primary responsibility for carrying out baseline monitoring in a manner that will meet the diverse data needs of state water protection and resource management programs. The state will continue to work with partners from the federal government, academia and the private sector, as well as volunteers, to carry out water monitoring programs. Enhanced coordination of monitoring can benefit the state by ensuring that useful data generated from sources outside of state programs are made available and incorporated into decision-making in state environmental programs. The newly formed RI Environmental Monitoring Collaborative (RIEMC) has an important role to play in facilitating coordination and communication among monitoring programs and closely tracking and evaluating the progress made by agencies to implement a comprehensive approach to environmental monitoring. DEM, in its capacity as the state water pollution control agency, is responsible for assessing the conditions of surface waters on a statewide basis in accordance with federal Clean Water Act requirements. The assessment process involves using monitoring data to determine if the designated uses for a specific body of water are attained or supported. All surface waters are designated for aquatic life, recreational and fish consumption uses. A portion of the state's surface waters area also designated for shellfishing or drinking water uses. Gaps in available monitoring data prevent a comprehensive assessment of surface waters for all designated uses. A review of monitoring programs reveals significant gaps in both the geographic coverage and type of data (parameters) being collected in monitoring programs. Compared with lakes and coastal waters, there are less data available from rivers and streams with 62% of river miles in the state categorized as *unassessed*. (RIDEM, 2004 305(b) report) Other major gaps

include data on the pollutant loadings from the largest rivers into coastal waters, the water quality conditions of coves and embayments, extent of fish tissue contamination and streamflow.

Percent of Waterbody Type Assessed for Specific Uses

Designated Use	Rivers & Streams (% of total miles)	Lakes & Ponds (% of total acreage)	Estuaries (% of total square miles)
Aquatic Life	36%	75%	75%
Recreation/Swimming	31%	70%	99.6%
Fish Consumption	<1%	2%	0

Source: RI DEM 2004 305(b) Report

Environmental Indicators & Monitoring Objectives

An effective monitoring and assessment program should be related to specific goals and objectives and a core set of environmental indicators. Recommended indicators for both freshwater and coastal waters are specified in the strategy and adapted from EPA guidance, a report produced by Kleinschmidt Associates for the Partnership for Narragansett Bay and state legislation. Monitoring programs have been included that will generate data to support measurement of a majority of the recommended indicators. The indicators include physical, chemical and biological parameters related to water resources. Being focused on water monitoring, this strategy does not address environmental indicators that are primarily terrestrial such as measuring changes in land use, extent of forest cover etc.

Data collected in support of the indicators will address priority state needs. Specific monitoring objectives include:

- Assessing changes in water quality in the Upper Bay as pollution controls are implemented;
- Quantifying reductions in pollutant loadings from wastewater treatment facilities and major tributaries discharging into the Bay;
- Assessing the presence and concentration of pathogens in coastal waters;
- Determining the extent of hypoxia in the Bay;
- Tracking trends in the abundance and distribution of finfish, shellfish and crustaceans in coastal waters;
- Assessing ambient water quality conditions in all rivers and streams by 2011;
- Assessing ambient water quality conditions in all lakes 20 acres or larger by 2011;
- Assessing fish tissue contamination in rivers, streams, lakes and ponds statewide by 2014;
- Tracking trends in the abundance and distribution of freshwater fish and anadromous fish;
- Reducing critical gaps in data on streamflow;
- Providing data to support measurement of water quality trends and changes in ecosystem functioning over longer periods of time.
- Provide data that supports the development and application of models in water resource programs (hydrodynamics, water quality ,etc.)

With respect to freshwater resources, the strategy envisions an expanded use of biological indicators. The collection of biological monitoring data provides a more direct reflection of the multiple stressors that may be adversely affecting aquatic ecosystems. Additional actions are recommended to build capacity in state programs to use data more effectively; e.g. development of indexes of biological integrity (IBIs) to support interpretations of biological data for water quality purposes. In some areas, such as estuarine biological indicators, additional research and analysis is needed to ascertain which specific new monitoring approaches should be added to the existing recommended programs.

Sampling Approaches and Designs

The monitoring strategy incorporates a mix of sampling approaches applied to different waterbody types. The approaches include a rotating basin approach, fixed-site networks and other variations of targeted sampling. Monitoring activities will be aligned within watersheds as much as possible to enhance the integration of data pertaining to water resource conditions within watersheds. The strategy builds on the existing capacity of monitoring programs in the state but also calls for new investment. Specifically, it envisions the creation of an ambient monitoring program within the DEM –Office of Water Resources comprised of staff with the necessary expertise to conduct both marine and freshwater monitoring. The strategy also identifies where other new investments will be needed to meet the overall data needs of state water quality and resource management programs. Overall, for the period of 2005-2010, the strategy recommends three new programs, re-institution of two programs, the enhancement of 7 existing programs and the maintenance of many others. Highlights of planned and recommended programs that support the assessment of baseline water quality conditions include:

Narragansett Bay and Coastal Waters

- Sustain and expand the network of fixed-stations that provides continuous monitoring on dissolved oxygen and other parameters in Narragansett Bay.
- Enhance the state's capacity to conduct rapid surveys of water quality conditions by purchasing equipment and training staff.
- Institute assessments of coastal ponds, coves and embayments on a rotating schedule aligned where feasible with the rotating basin approach for freshwater rivers.
- Sustain the Shellfish Growing Area Monitoring program and increase frequency of sampling in permanently closed areas as pollution abatement actions are implemented.
- Sustain the Bathing Beach Monitoring Program.
- Sustain regular monitoring of the estuarine Providence and Seekonk Rivers which receive wastewater treatment facility discharges.
- Encourage continued volunteer-based monitoring of coastal waters to provide supplemental data to state programs, particularly in areas otherwise monitored periodically.
- Sustain marine fisheries surveys and expand range into RI & Block Island Sounds.
- Sustain existing system to measure tides and currents and collect additional data where needed to enhance understanding of the hydrodynamics of coastal waters.

Rivers and Streams

- Adopt a rotating basin approach to monitor rivers and streams. Dividing state into 7 watershed assessment unit, complete monitoring of all seven within a five year timeframe. Employ an intensive, geometric sampling design that integrates physical, chemical and biological data. (Note: The specific configuration of watershed –based assessment units will be selected after further review of several state programs that conduct work on a watershed basis with the aim of aligning work as feasible to enhance the understanding of watershed conditions.)
- Re-institute water quality monitoring at selected fixed-site stations on the state's largest rivers: Blackstone, Pawtuxet, Pawcatuck. Increase the number of stations to 8 and the frequency of monitoring to monthly to improve measurements of nutrient pollutant loadings into Narragansett Bay and coastal waters. Re-institute biological monitoring in association at these locations.
- Ensure that the Taunton River in Massachusetts is adequately and reliably monitored by appropriate entities in Massachusetts.
- Institute a fish tissue contamination program in rivers that is aligned with the framework of the rotating basin approach.
- Maintain monitoring of pathogens in rivers subject to combined sewer overflows.
- Expand the network of gages that are used to measure streamflow.
- Encourage volunteer-based monitoring of rivers and streams to supplement the rotating basin approach.

Lakes and Ponds

- Support the URI-Watershed Watch Program in its role of coordinating volunteer-based monitoring.
- Expand the number of lakes monitored by volunteers and provide capacity within the URI-WW program to support assessment of all lakes 20 acres or larger.
- Institute a fish tissue contamination program in lakes and ponds.
- Expand the bathing beach program in lakes and ponds to apply a risk-based approach comparable to that applied in coastal waters.
- Continue implementation of the public drinking water supply program requirements regarding monitoring.

Details on the above programs can be found in summary table at the end of this section.

In addition to the programs outlined above, within state government, it is expected that monitoring for certain program specific purposes will continue including: (1) effluent monitoring required via the RIPDES Program, (2) water quality investigations completed via the TMDL Program, (3) other permit-related and compliance monitoring required by DEM, (4) basins studies coordinated by the WRB; (5) monitoring the effectiveness of best management practices; e.g. stormwater treatment systems, by DEM and DOT and (6) various special studies or projects.

Future Strategy Revisions

The current strategy reflects ambient monitoring related primarily to water quality and fisheries management, but recognizes the need to incorporate additional monitoring programs to provide the comprehensive monitoring framework that fully supports all water management program needs. Further review and discussion will be needed to build a consensus on what types of additional monitoring activities are needed. The RI Environmental Monitoring Collaborative has initiated such discussions and is expected to continue to provide a forum to develop and refine the overall monitoring framework. The water monitoring strategy will be periodically reviewed and updated to incorporate new indicators and monitoring programs as needed to support an adaptive management approach to water quality and natural resource protection in Rhode Island.

The following topic areas, all related to management concerns within state water programs, may require the development of additional monitoring strategies in order to provide state managers with needed data. In many cases, past and present monitoring activities have provided some data and experience from which to devise appropriate long-term monitoring approaches.

- Mapping benthic habitat in coastal waters.
- Periodically measuring the extent of submerged aquatic vegetation (SAVs).
- Long-term strategy for monitoring bioinvasives in coastal waters.
- Monitoring phytoplankton (primary productivity) in coastal waters.
- Monitoring zooplankton in coastal waters.
- Assessing fish tissue contamination in coastal waters.
- Monitoring the extent of nuisance aquatic weeds in lakes and ponds.
- Long-term strategy for monitoring bioinvasives in freshwaters.
- Nutrient criteria development in freshwaters and coastal waters.
- Measuring sediment quality.
- Bioassessment of coastal and freshwater wetlands.
- Assessing groundwater quality
- Emerging pollutants of concern; e.g. pharmaceuticals

DEM is planning additions to the strategy to incorporate recommendations that address federal and state mandates or management priorities. In 2006, these will include: monitoring freshwater wetlands, SAVs, and nutrients in coastal waters. In 2007, planned additions include: coastal wetlands, groundwater quality, nutrients in freshwaters, and benthic community and sediments in coastal waters. Other recommendations will be developed as resources allow and pursuant to the work of the RIEMC and direction of the Coordination Team. As part of a prioritization exercise conducted earlier in 2005, the RIEMC ranked the monitoring programs proposed as enhancements to the planned

existing efforts. In addition to the ambient water quality programs proposed for enhancement by DEM, the following ranked as the highest priorities: fish tissue contamination, expanding the streamflow gage network, developing a plan for bioinvasives and macroalgae surveys in the Bay.

Quality Assurance (QA)

All state monitoring programs, as well as those other programs contributing data to state decision-making, should have written quality assurance plans that address how the quality of data is assured. A preliminary review indicates that most programs operate with appropriate QA plans in place. Steps are being taken in some programs, such as the fixed-station network in Narragansett Bay, to standardize operating procedures and data management protocols in order to enhance consistency in the data sets being generated.

Data Management and Analysis

Data management is an inherent activity within individual monitoring programs. From a state perspective, data management activities are currently decentralized and dispersed among agencies and entities engaged in monitoring. Mechanisms to integrate and synthesize data across programs are not widely institutionalized. There is no central system for archiving data over time within state government and accessibility to data is variable. The DEM-OWR currently maintains and utilizes databases that combine water quality data from multiple sources in order to carry out its periodic assessment of water quality conditions. However, not all available data is entered into this system. With respect to data management and dissemination, DEM is developing the capacity for participation in the Environmental Information Exchange Network, a national network connecting states, EPA and other data users. As part of this system improvement, a new water quality database is planned and uploads of data to STORET (a national database) for archiving will be automated. Additional evaluation of data system needs among monitoring programs and data users is needed in order to support more specific recommendations on improving data management, including accessibility and integration. There is a need to integrate or link databases to support data synthesis on a watershed basis. Long-term, an effective data management system will need to support the day-to-day operations within programs, facilitate data sharing and public dissemination of information, and provide for archiving data via a data warehousing function. It is envisioned that such a system will have a geographical information system (GIS) as an essential component. Further evaluation of data system needs should be coordinated via the RIEMC and will require investment in both planning and implementation.

Implementation

The strategy builds on existing monitoring programs and acknowledges that enhancements and expansions of programs will need to be phased in over the next several years. It is important to ensure the continued operation of the fixed-site network operating in Narragansett Bay. Several new initiatives are proposed to address major gaps in existing data. These include instituting a rotating basin approach to assess rivers and streams, conducting a rotational assessments of coastal ponds, coves and embayments, institution of sampling to measure fish tissue contamination, resuming regular monitoring of large rivers and expanding the network of streamflow gages. With respect to water quality, the strategy recommends establishing an ambient monitoring program within the DEM Office of Water Resources consisting of a monitoring coordinator and appropriate number of staff dedicated to the function of conducting ambient monitoring programs.

While expanding capacity within state agency monitoring programs, the strategy also envisions continued collaboration on monitoring programs between the state and its partners including the federal government, academia and local organizations as well as volunteers. Opportunities to leverage resources in support of monitoring should be vigorously pursued. Full implementation of the recommended water monitoring strategies is estimated to require about \$5.47million in FY2007. After estimating expected available funding, an additional investment of \$1.98 million is identified as needed to fully fund the initial implementation of the recommendations.

Summary of Recommended Monitoring Programs – September 2005

Waterbody Type	Core Indicator	Primary Use of Data in State Water Programs	Program	Agency/ Organization	Geographic Scope & Sampling Design	Current Program Status (2006)	Estimated Annual Cost FY2007
Coastal Waters	Dissolved Oxygen and other physical/ chemical parameters	<ul style="list-style-type: none"> Assess effectiveness of WWTF upgrades Screen for conditions that may result in events such as fish kills Assess water quality conditions; Identify impaired (polluted) waters; Measure water quality trends over time; 	Fixed-Site Monitoring Network	DEM-OWR NBNERR NBC URI-GSO RWU	13 existing fixed –site stations operating from buoys or docks in Narragansett Bay; instruments collect data on a continuous basis; e.g. every 15 minutes	Existing with 13 stations Plans for expansion	\$634,000*
		<ul style="list-style-type: none"> Determine extent of hypoxia in upper bay; Screen a larger area for conditions that may result in events such as fish kills 	Rapid DO surveys in upper Bay	NBEP DEM	Periodic targeted surveys using three boats in cover the upper half of Narragansett Bay; grab samples collected from fixed points along transects	Existing with expansion recommended	\$103,000
		<ul style="list-style-type: none"> Assess water quality conditions; Identify impaired waters; Measure water quality trends over time; 	Rotating assessment of coastal waters	DEM-OWR	7 coastal ponds and 19 embayments – to be assessed over 5 year period; deployment of fixed-site continuous stations supplemented with grab samples	New	\$250,000
		<ul style="list-style-type: none"> Discern changes as WWTF improvements are implemented 	Estuarine River Monitoring – Nutrients	NBC	Seekonk and Providence Rivers; number of stations to be determined (10-12).	New program planned for 2005	\$45,000 (Includes costs for tributaries)
	Pathogens	<ul style="list-style-type: none"> Open/close shellfishing growing areas; Assess shellfishing use; Assess recreational use; 	Shellfish Growing Area Monitoring	DEM-OWR	303 fixed- stations in coastal waters; grab samples	Existing with expansion recommended	\$302,250
		<ul style="list-style-type: none"> Close bathing beaches; Assess recreational use; 	Bathing Beach Monitoring	HEALTH	70 coastal water beaches	Existing	See (A) in multi-waterbody types below.
		<ul style="list-style-type: none"> Measure water quality conditions and discern changes as CSO abatement proceeds 	Fecal and Enterococcus Monitoring	NBC	Providence River – 19 sites	Existing	\$ 40,000
		<ul style="list-style-type: none"> Target state monitoring; Provide supplemental data to track TMDL implementation; Provide supplemental data between basin rotations 	Volunteer-based programs in coastal waters	URI-WWV	Salt Ponds, Narrow River	Existing	See (B) in multi-waterbody types below.
	Toxics in Fish Tissue	<ul style="list-style-type: none"> Fish consumption advisories to protect public health; Assess fish consumption use; 	Fish Tissue Monitoring	DEM-OWR & HEALTH	To be determined	Future	0
	Biological	<ul style="list-style-type: none"> Fisheries Management 	Finfish Surveys	DEM-F&W		Existing with expansion	\$1,619,200
			Shellfish surveys	DEM-F&W		Existing	
			Lobster Surveys	DEM-F&W		Existing	
			Horseshoe Crab surveys	DEM-F&W		Existing	
	Circulation – Tides	<ul style="list-style-type: none"> Input and validation of water quality models; Understanding Bay hydrodynamics 	PORTS & Tidal stations	NOAA	5 stations in the Bay in RI; one in Fall River	Existing	\$250,000

Waterbody Type	Core Indicator	Primary Use of Data in State Water Programs	Program	Agency/ Organization	Geographic Scope & Sampling Design	Current Program Status	Estimated Annual Cost FY2007
Rivers and Streams	Chemical and physical parameters- DO, nutrients, metals etc.	<ul style="list-style-type: none"> Compare current water quality data to standards and criteria designed to protect aquatic life; Identify impaired waters; Measure water quality trends over time; Assess impacts of WWTF dischargers Measure pollutant loadings into coastal waters; 	Rotating Basin Assessments of Rivers and Streams	DEM-OWR	Statewide - 7 watershed basin assessment units; 1-2 basins assessed each year over 5 year period using intensive sampling design.	New Completion of demonstration project	\$435,000
			Fixed-station River Monitoring	USGS with DEM funding	8 locations in Rhode Island on the Blackstone, Pawtuxet and Pawcatuck Rivers; one station on the Taunton River in MA. Monthly or quarterly sampling frequency.	Re-establish with expansion of effort	\$75,000
			Tributary Nutrient Monitoring	NBC	5 Main tributaries – biweekly in sampling season	New in Spring 2005	\$225,000
		<ul style="list-style-type: none"> Assess water quality conditions; Provide supplemental data between basin rotations Provide supplemental data to track TMDL implementation; 	Volunteer-based Monitoring of Streams	URI-WW	Over 35 sites on 10+ rivers and streams	Existing	Included above
	Pathogens	<ul style="list-style-type: none"> Assess bacterial contamination in rivers affected by NBC wastewater system; e.g. CSOs. Assess recreational use; 	Regional Pathogen Monitoring in Rivers	NBC	18 fixed stations on tributaries to Providence River (Moshassuck, Blackstone, Woonasquatucket and West)	Existing	\$65,000
		<ul style="list-style-type: none"> Assess recreational use; Identify threats to public health due to impaired waters; 	Rotating Basin Assessments of Rivers & Streams	DEM-OWR	Statewide -7 watershed basin assessment units; 1-2 basins assessed each year over 5 year period using intensive sampling design.	New	Included in above costs.
	Toxics in Fish Tissue	<ul style="list-style-type: none"> Fish consumption advisories to protect public health; Assess fish consumption use; 	Fish Tissue Contamination	DEM-OWR & HEALTH	Statewide- Targeted sampling aligned with rotating basin schedule	New	\$130,000
	Biological Macro-invertebrates	<ul style="list-style-type: none"> Compare current water quality data to standards and criteria designed to protect aquatic life; Long-term water quality trends; Identify impaired waters 	Biological Sampling – Fixed Sites	DEM-OWR	Sampling aligned with 8 fixed site stations (see above)	Re-institute program	Included in above costs
			Rotating Basin Assessments of Rivers and Streams	DEM-OWR	Statewide - 7 watershed basin assessment units; 1-2 basins assessed each year over 5 year period using intensive sampling design.	New (modification of existing program)	Included in above costs
	Fish Assemblage	<ul style="list-style-type: none"> Develop an IBI to support water quality assessment; Fisheries management. 	Rotating Basin Assessments of Rivers and Streams	DEM-OWR	Statewide - 7 watershed basin assessment units; 1-2 basins assessed each year over 5 year period using intensive sampling design.	Future	To be determined
			Freshwater Fisheries	DEM- FW	Anadromous Fish – selected streams	Existing	\$216,000
	Streamflow/ Water Quantity	<ul style="list-style-type: none"> Water quality applications (models, permits, etc.) Drought management. Water resource allocation. 	Streamflow Gaging Network	USGS with DEM & WRB	20 existing gages maintained; ten additional gages proposed for expansion	Existing with expansion	\$270,000

Waterbody Type	Core Indicator	Primary Use of Data in State Water Programs	Program	Agency/ Organization	Geographic Scope & Sampling Design	Current Program Status	Estimated Annual Cost FY2007
Lakes and Ponds	Chemical and physical parameters	<ul style="list-style-type: none"> Compare current water quality data to standards and criteria designed to protect aquatic life; Identify impaired waters; Measure water quality trends over time 	Watershed Watch Program	URI-WW	Statewide – larger lakes and ponds	Existing with recommended expansion	See (B) below.
	Pathogens	<ul style="list-style-type: none"> Open and close bathing beaches on lakes/ponds. Assess recreational use; Identify threats to public health due to impaired waters; 	Bathing Beach Program	HEALTH		Existing with recommended expansion	See (A) below.
			Watershed Watch Program	URI-WW	Statewide – larger lakes and ponds	Existing with planned expansion.	See (B) below.
	Biological Freshwater Fisheries	<ul style="list-style-type: none"> Fisheries Management 	Largemouth Bass	DEM-FW	Statewide – larger lakes and ponds	Existing	\$216,000
	Toxics in Fish Tissue	<ul style="list-style-type: none"> Fish consumption advisories Assess fish consumption use 		DEM-OWR w/ DOH	Statewide – larger lakes and ponds	New	\$50,000
Multiple Waterbody types	Pathogens	<ul style="list-style-type: none"> Open and close bathing beaches 	Bathing Beach Program	HEALTH	118 beaches statewide	Existing with recommended expansion	(A) \$317,000
	Chemical, physical and pathogens	<ul style="list-style-type: none"> Assessment of designated uses Water quality trends 	Watershed Watch Program	URI-WW	Statewide	Existing with recommended expansion	(B) \$231,000
Total Estimated Resources to support full implementation of field monitoring programs							\$5,473,450
Shortfall after accounting for anticipated funding available for FY2007							(\$1,985,983)

* Costs for RWU not included.

1.0 The Role of Monitoring in Water Quality Management

1.1 Purpose and Scope

Water monitoring, when based on a comprehensive and rigorous system of environmental indicators, is an essential component of the state's overall approach to protecting and restoring its vital water resources. To be used effectively, monitoring data must be accompanied by an integrated assessment or analysis process that provides needed meaning to the data. Meaningful information, derived from data, is relied upon to produce accurate and proportionate management actions aimed at protecting, managing and restoring water resources. An effective water monitoring strategy is intended to achieve a better return on public and private investments in environmental protection, pollution control and natural resources management. In short, more and better monitoring and assessment information is needed to answer the fundamental questions that have been repeatedly asked about the condition of our water resources and to shape the strategies needed to deal with both existing and emerging problems. The Rhode Island Department of Environmental Management (DEM) undertook the task of developing a comprehensive surface water monitoring strategy with the aim of acquiring sufficient capacity to deliver this type of information for decision-making in water resource programs. In this effort DEM was assisted by the New England Interstate Water Pollution Control Commission (NEIWPCC) and Christopher Yoder, a consultant with the Midwest Biological Institute (MBI), who drafted portions of this document.

During development of this strategy, the Rhode Island Environmental Monitoring Collaborative (RIEMC) was formed, pursuant to new state law, and charged with developing a comprehensive monitoring program. This strategy constitutes an important component of the broader strategy that the RIEMC is developing and that is intended to serve the needs of the new Coordination Team that is collaborating on bay, river and watershed management. The RIEMC has an important role to play in facilitating the coordination, communication and evaluating progress toward achieving implementation of a comprehensive monitoring program. Monitoring programs will be implemented by the agencies with corresponding management responsibility, most of which serve on the RIEMC. Working with the RIEMC, DEM expects this strategy to be refined over time. The Water Monitoring Strategy will be reviewed every three years and adjusted in order to meet the changing data needs of state programs and support adaptive management. The RIEMC will also be reporting annually to the Governor and General Assembly on the progress of implementing monitoring programs.

This strategy describes the approaches, sampling designs and other related actions that are needed to implement an effective, comprehensive monitoring program for surface waters in Rhode Island. It also outlines the resources that will be needed to support implementation. This strategy is responsive to the mandates of state and federal law and is designed to support the following purposes:

- 1) conduct an inventory of water resources;
- 2) determine ambient water quality conditions and assess trends in condition;
- 3) characterize the physical characteristics of surface waters; e.g. streamflows;
- 4) identify causes and sources of water quality problems including emerging water pollution problems;
- 5) identify threats to public health associated with water pollution;
- 6) develop and implement a variety of resource management programs aimed at protecting and restoring water quality; managing water quantities; including drought management; protecting and restoring aquatic and marine ecosystems, managing fisheries and protecting public health.
- 7) evaluate the effectiveness of water resource programs, including pollution control efforts;
- 8) respond to emergencies.

If fully implemented as outlined, it will provide data to measure important environmental indicators and allow Rhode Island to achieve the goal of comprehensively assessing its surface waters for all designated uses by 2014. With the exception of small ponds, all waters will be assessed for aquatic life, recreational and shellfish uses, as applicable, by 2011. It is a fundamental vision of this strategy that ambient monitoring and assessment will function to support all

water resource management programs in addition to its more commonplace role of characterizing water quality conditions.

The strategy currently applies to all surface waters including rivers and streams, lakes and ponds and coastal waters. It provides a multi-agency framework that is focused on monitoring the ambient condition of the state's water resources, but also references and integrates, as appropriate, other targeted monitoring activities carried out by the state and other entities. It reflects the responsibilities DEM has with respect to monitoring and assessing the state's waters and reporting on their status to EPA. To fulfill Environmental Protection Agency (EPA) requirements, DEM plans to expand the scope of the strategy over the next several years to incorporate monitoring strategies for groundwaters, freshwater and coastal wetlands, and sediments. DEM has developed a monitoring and assessment strategy for freshwater wetlands as a separate initiative that will be integrated into this document in 2006.

1.2 Background – The Need for Adequate Monitoring and Assessment

In previous decades few, if any, state monitoring programs were sufficiently funded, developed, or designed to deliver an accounting of environmental results on a systematic basis. Inevitable questions about the results of the large expenditures of public and private funds could not be satisfactorily answered by most state and federal agencies, a situation that persists into the present (National Research Council 2001; GAO 2003). This resulted in a number of efforts to revitalize environmental monitoring at the federal level, the most noteworthy of which was the Intergovernmental Task Force on Monitoring Water Quality (ITFM 1992, 1995). When coupled with the technical developments in sampling methods, use of environmental indicators, data management, and assessment tools that occurred during the same period, this delivered the type of process that was needed earlier. A document entitled *Important Concepts and Elements of an Adequate State Watershed Monitoring and Assessment Program* (Yoder, 1998) details the conceptual basis for accomplishing adequacy and greater effectiveness in monitoring and assessment. Information from *adequate* monitoring and assessment is critical to the ability of the state and others to track, manage, and report on water quality and the important attributes that comprise and indicate that quality.

Adequate monitoring and, by extension, water quality management, requires a sufficient infrastructure and capacity in terms of personnel, facilities, and logistical support. It is important to note that progress in reaching the goal of adequacy in monitoring programs requires several years to accomplish. (Yoder 1998, MBI 2003) Improving monitoring is a task that has been forced to compete with other water program priorities and crises. A recent survey indicated state programs have only half the resources needed to execute adequate monitoring and assessment programs. (ASIWPCA, 2003). Initial estimates of the proportion of a state water quality management program that should be dedicated to monitoring and assessment activities ranges from 15-20% in terms of staffing and funding (although this may vary from place to place) (MBI, 2003). Rhode Island has historically not achieved this level of investment.

An adequate monitoring and assessment framework includes consideration of the spatial and temporal design of the data collection; the development of chemical, physical, and biological indicators; the processes used to assemble the data and information into meaningful assessments; and the organizational infrastructure within which it is accomplished. A fundamental premise of adequate monitoring and assessment is that it be conducted at the same spatial scale at which management takes place. This simple premise allows management policies, approaches, and activities to be linked more closely to their environmental consequences as revealed by monitoring and assessment. The monitoring framework included herein aims to achieve more than the mere collection of environmental data, but rather emphasizes the development of assessments based on that data. The framework is also aimed at accomplishing the long-held objective of better integrating available environmental information into management decision-making. This goes well beyond the often-emphasized task of assessing status and trends in water quality and includes the much more difficult task of realizing integration with water quality management programs on a day-to-day basis.

1.3 State Water Program Data Needs

Monitoring and assessment provides an integral function in water quality management by validating the environmental outcomes of management program outputs. It provides the essential feedback about the effectiveness of State efforts to manage water quality and aquatic resources. Given the complexity of water resource programs, there are significant data needs among the several agencies and entities involved in the management, protection and restoration of water resources. These needs extend beyond the requirements of the Clean Water Act.

The state has a responsibility to meet its data needs in a cost-effective manner. Toward this end, the state needs to continue to develop and encourage uniform methods and consistent quality assurance procedures among programs to enhance the value of shared data. Appendix A includes a listing of specific data needs organized by state water program. The list is not intended to be all-inclusive, but rather an outline of priority needs and uses of water quality data and information in state programs.

Examples of priority data needs include:

- Identifying waters that are polluted or impaired;
- Identifying sources of pollution;
- Characterizing the extent and nature of water pollution problems;
- Characterizing public health threats associated with water pollution;
- Characterizing water quantities and managing drought conditions;
- Evaluating permit compliance;
- Determining the abundance and species composition of aquatic biological communities;
- Enhancing understanding of ecosystems, including the life cycles of aquatic biota;
- Establishing background water quality conditions;
- Refining water quality standards.

1.4 Recent Reviews of Monitoring and Assessment in Rhode Island

In recognition of the need to improve monitoring and assessment relative to Narragansett Bay and its watersheds, in 2000 the Partnership for Narragansett Bay (PNB) initiated an intensive process to assess current monitoring programs related to the Bay and its watershed and to initiate development of ecological indicators. The goal was to strengthen the ability to track ecosystem conditions and to provide information that would help scientists, resource managers and the public decide if the Bay is better or worse off than in previous times. Facilitated through the University of Rhode Island (URI) Coastal Institute, two workshops were conducted: "Environmental Monitoring in Rhode Island: A Synthesis" in June 2001 and "Developing Environmental Indicators- Vital Signs for Narragansett Bay and Coastal Ponds" in October 2001. Summaries of the workshops are available on-line via the Coastal Institute at www.ci.uri.edu/Projects.

As a result of the PNB process, a monitoring program database was compiled that documented for the first time a comprehensive inventory of on-going monitoring programs conducted by federal, state and local government, non-profit organizations, and academic institutions that related to protection and management of Narragansett Bay. It included over 90 listings and remains available via the Coastal Institute's web-site at <http://www.ci.uri.edu/Projects/mon>. The newly formed Monitoring Collaborative completed an update of the inventory in advance of its January 2005 report..

The well attended PNB workshops produced five key findings regarding the status of monitoring in Rhode Island that remain largely applicable today. These are:

1. Monitoring in Rhode Island is seriously underfunded, particularly programs run by the state.

2. Significant monitoring data gaps exist.
3. There is a lack of coordination of monitoring efforts.
4. There is a lack of integration of analyses of existing data and interpretation as indicators.
5. There is increasing federal pressure to report environmental results to the public and decision-makers and increase accountability.

The workshops also produced recommended actions associated with these findings which have been considered in the development of this strategy.

In August 2003, a massive fish kill in Greenwich Bay focused attention on the water quality conditions of Narragansett Bay. Scientists and others examining the event found that while there was a good understanding of what happened, more data and information was needed to fully characterize the impacts of this event. The direct cause of the death of marine life was a lack of oxygen. A complex interaction of several factors resulted in an extended period of oxygen depletion in the Greenwich Bay area. A report by DEM reviewing the fish kill event included several recommendations for improving monitoring including the need for developing a comprehensive monitoring strategy for the Bay, enhanced capabilities to conduct rapid mapping of hypoxic zones and further characterization of benthic conditions among others. (RIDEM, 2003)

Following the fish kill and an increased number of beach closures in 2003, the Rhode Island legislature as well as the Governor undertook initiatives that resulted in further examination of monitoring programs. Governor Carcieri organized the Narragansett Bay and Watershed Planning Commission. This Commission formed ten panels consisting of over 160 experts to review various issues and make recommendations for improved management of the Bay and its watershed. One panel was charged to specifically address the topic of monitoring. Consistent with the PNB findings, the panel found that a comprehensive, efficient and coordinated monitoring framework did not exist. It noted that the absence of a comprehensive strategy severely limits the state's ability to evaluate environmental disasters such as fish kills or large oil spills. It emphasized that a new monitoring strategy should promote better coordination, cooperation and collaboration among state and federal agencies, academic institutions, private entities and volunteer-based monitoring organizations. It recommended that a mechanism, such as a monitoring council, be established to facilitate coordination. As a short-term action the Commission Interim Report (GNBWPC, 2004) recommended that it was necessary to "Develop an improved, expanded, and strengthened watershed-wide monitoring and response program that will share information on the Bay's health and trends among scientists, decision-makers and the public. This information will allow for continual, results-oriented performance assessments, feeding an adaptive management plan that responds to the Bay's needs; and makes the public aware of whether or not we are protecting Narragansett Bay". To accomplish this task, the Commission report further recommended the (1) development of a new monitoring plan, along with any necessary inter-agency or interstate agreements needed to implement the monitoring program; and (2) development of a program to systematically monitor and report land-use changes, habitat loss, impervious surface, and human demographics changes in the Bay watershed. Additionally, the report called for ensuring that monitoring programs include "plans and resources for on-going data synthesis, analysis, and reporting to all audiences in prompt and reliable fashion", and be supported by a coordinated Bay data management system.

The RI Senate Joint Committees on Government Oversight and Environment and Agriculture evaluated the topic of monitoring during hearings conducted on the management of Narragansett Bay held during November and December 2003. The Senate Committee's work was summarized in a report to the Senate in February 2004. The report concluded that while "an array of monitoring is taking place ...long-term stability is needed, gaps need to be filled and coordination needs to be provided." To enhance existing monitoring programs in Narragansett Bay and the marine environment, the report recommended two short-term actions: (1) "create a coordinating and management structure for monitoring programs that will develop a central data management system for monitoring initiatives and improve coordination and cooperation between monitoring programs of different institutions and agencies"; and (2) "Provide dedicated long-term funding for DEM's shellfish bed and river water quality monitoring programs and for DOH's beach monitoring program." (RI Senate, 2004)

The House of Representatives established the Bay Trust Study Commission which issued a report in March 2004. While primarily focused on studying the system for policy formulation and planning for environmental management and sustainable economic development of bays and watersheds, the report identified that a key element of success for any system was a monitoring program. It noted “consistent and coordinated monitoring programs have proved to be critical in identifying and prioritizing management initiatives, and in evaluating progress using quantifiable measures.” (RI House of Representatives, 2004)

In June 2004, the legislature acted on these reviews and passed new state laws pertaining to monitoring which are further outlined in section 1. 6.

1.5 Federal Requirements and Guidance

This strategy has been developed to comply with applicable federal guidance that affects state water quality management programs. With respect to ambient monitoring, RIDEM must comply with federal requirements and guidelines issued by U.S. EPA pursuant to the federal Clean Water Act. Past monitoring and assessment activities have been conducted under the initial guidance issued by EPA in 1994. (U.S. EPA 1994). This guidance was recently updated with EPA’s publishing of Elements of a State Water Monitoring and Assessment Program (U.S. EPA 2003). The *Elements* document recommends the basic elements of a state water monitoring and assessment program. This guidance is intended to provide a framework for states to clearly articulate their programmatic and resource needs and a reasonable time line for meeting those needs. The *Elements* document further clarifies its intent as follows:

“EPA and states need comprehensive water quality monitoring and assessment information on environmental conditions and changes over time to help set levels of protection in water quality standards and to identify problem areas that are emerging or that need additional regulatory and non-regulatory actions to support water quality management decisions such as TMDLs, NPDES permits, enforcement, and nonpoint source management. This information also informs EPA and state decision-makers, the Congress, the public, and other stakeholders of the progress that the Agency and state partners are making in protecting human health and the environment. Without this information, it is difficult for EPA and the states to set priorities, evaluate the success of programs and activities, and report on accomplishments in a credible and informed way (U.S. GAO 2000).”

As such, monitoring and assessment is clearly viewed as a program support function for all water quality management activities, not just reporting on water quality status and trends. Monitoring strategies will be state specific and designed to build upon the monitoring capabilities each state already has.

The 10 elements outlined in EPA’s guidance are:

- 1) **Monitoring strategy** - a long-term and detailed implementation plan not to exceed ten years. The strategy should incorporate or reference the remaining elements listed below.
- 2) **Monitoring Objectives** – these are critical to the design of a monitoring program that is efficient and effective in generating data that serves management decision needs. The objectives should reflect the goals and requirements of the federal Clean Water Act and relevant state law.
- 3) **Monitoring Design** - an approach and rationale for the selection of a mix of monitoring designs and sample sites that best serves the monitoring objectives. The strategy should be comprehensive with a goal of assessing all state waters on a periodic basis. Many states already employ a five-year rotating basin design. The design should produce scientifically valid data that meets the needs of resource managers and decision-makers. Sampling locations should be established in consistent with EPA Locational Data Policy (US EPA, 1994)
- 4) **Core and Supplemental Water Indicators** - a tiered approach to monitoring that includes core indicators selected to represent each applicable designated use, plus supplemental indicators selected according to site-specific or project-specific decision criteria. Multiple indicators should be used to encompass chemical, physical and biological measures and be relevant to water quality management issues being assessed.

- 5) **Quality Assurance** - quality management plans and quality assurance program/project plans are established, maintained, and peer reviewed to ensure the scientific validity of monitoring and laboratory activities, and to ensure that state reporting requirements are met. When the state uses federal EPA funds to support monitoring, QAAP are mandatory.
- 6) **Data Management** - an accessible electronic data system for water quality, fish tissue, toxicity, sediment chemistry, habitat, biological data, that timely data entry, data description, and public access standards. Data should be stored in manner to allow easy retrieval and analysis and support data sharing between agencies and institutions. Water quality data should be uploaded into EPA STORET and assessment results stored in Assessment Database (ADB).
- 7) **Data Analysis and Assessment** - methodologies for assessing attainment of water quality standards based on analysis of various types of data (chemical, physical, biological, land use) from various sources, for all waterbody types and all state waters are developed and used. This is being developed by the DEM-OWR is a separate document.
- 8) **Reporting** - timely and complete water quality reports and lists called for under Sections 305[b], 303[d], 314, and 319 of the Clean Water Act and Section 406 of the Beaches Act are published.
- 9) **Programmatic Evaluation** - the state, in consultation with its EPA Region, conducts periodic reviews of each aspect of its monitoring program to determine how well the program serves its water quality decision needs for all state waters, including all waterbody types.
- 10) **General Support and Infrastructure Planning** - the state identifies current and future resource needs it requires to fully implement the monitoring program strategy.

Other Federal Requirements

Within selected state programs that conduct monitoring, there are additional federal requirements applicable to specific monitoring activities conducted by the state. In some cases the requirements are mandatory and enforced via federally delegated or approved programs. In other cases, the requirements are outlined in guidance, grant conditions or policies. In general, the federal requirements specify minimum requirements for which a state program can be no less stringent. Federal programs generally do not constrain the state from exceeding the requirements if needed. A listing of state water programs in which monitoring programs are affected by federal requirements is in Appendix B.

1.6 State Requirements and Guidance

Several state statutes are pertinent to the development of this monitoring strategy. A state mandate to create a comprehensive monitoring program was codified by legislative action in June 2004. "The Comprehensive Watershed and Marine Monitoring Act of 2004", formally established the Rhode Island Environmental Monitoring Collaborative (RIEMC) and directed that it develop and implement a state monitoring strategy that addresses critical state resource management needs. (RIGL 46-23.2) While the law focuses on marine waters, it has provisions which apply to all waters of the state and it is the intention of the RIEMC to address both marine waters as well as inland watershed monitoring needs. By law, the strategy must include the following elements:

- An inventory of existing monitoring programs;
- An outline of additional monitoring programs the state needs;
- A list of indicators that will be used to measure the health of marine habitats of the state;
- A list of data standards and protocols that will be used on a reasonable and consistent basis by monitoring programs that contribute data to the state monitoring system;
- A mechanism for data sharing among all monitoring programs that enables both monitors and users to securely access monitoring data via the internet and retain the integrity of such data;
- A plan to provide data from the state marine monitoring system for disaster prevention, preparedness, response and recovery efforts in the marine environment;
- A communication strategy to provide for public access to monitoring data.

State law requires the environmental monitoring strategy be updated every three years. Additionally, an annual progress report to the Governor and General Assembly from the RIEMC is required. Preparation of this report will be coordinated with the Coordination Team.

With respect to Narragansett Bay and its watersheds, separate legislation (RIGL 46-31) was also enacted to formally create the Rhode Island Bays, Rivers and Watersheds Coordination Team, hereafter referred to as the Coordination Team. Consisting of state governmental entities, it is charged with collaborating and coordinating resource management with respect to the Bay and its watershed. The statute creates a systems-level planning effort intended to enhance protection and management of Narragansett Bay and its watershed. This statute also authorizes the RIEMC and directs that a comprehensive monitoring plan be developed by the RIEMC and adopted by the Coordination Team. The new Coordination Team has initiated its work, and the RIEMC reports to and supports the work of the Coordination Team. Table 1 includes a list of state laws pertinent to monitoring programs.

Table 1. State Laws Pertinent to Water Monitoring Programs

State Law	Description
RIGL 46-23.2 (new) "The Comprehensive Watershed and Marine Monitoring Act of 2004"	<ul style="list-style-type: none"> Establishes the Rhode Island Environmental Monitoring Collaborative (RIEMC) Mandates a comprehensive monitoring plan and specifies requirements
RIGL 46-31 (new) "The Rhode Island Bays, Rivers and Watersheds Coordination Team"	<ul style="list-style-type: none"> Establishes a coordination team of seven state agencies: DEM, CRMC, DOA, RIWRB, RI Rivers Council, EDC and NBC Mandate a systems-level plan for the management, preservation and restoration of the state's bays, rivers and watersheds and promotion of sustainable economic development related to water resources; Authorizes the RIEMC and mandates an environmental monitoring strategy.
RIGL 42-17.1 "Department of Environmental Management"	<ul style="list-style-type: none"> Establishes DEM and vests Director with broad authority for protecting and managing the state's natural resources, including waters of the state.
RIGL 46-12 "Water Pollution Control Act"	<ul style="list-style-type: none"> Designates DEM as the state water pollution control agency for purposes of the federal Clean Water Act; Assigns duties to prevent, control and abate water pollution; Authorizes water quality standards and classification of surface waters (46-12-3(7)); water pollution studies, investigations or research (46-12-3(6)); collecting and disseminating information relating to water pollution (46-12-3(6)). Established in 1983 a monitoring program (Sherlock Program) supported by fees on certain point source dischargers. Currently analyze effluent at least annually from 23 dischargers for conventional and toxic pollutants.
RIGL 20-8.1 "Shellfish Grounds"	<ul style="list-style-type: none"> Establishes the shellfish program in DEM
RIGL 20-1 "Fish and Wildlife"	<ul style="list-style-type: none"> Vests authority for managing fish and wildlife resources in DEM
RIGL 23-21 Licensing of Recreational Facilities"; RIGL 23-21.1 (new) "Sanitation Standards for Bathing Beaches"	<ul style="list-style-type: none"> Authority for the bathing beach monitoring program in HEALTH
RIGL 46-13 "Public Drinking Water Supply"	<ul style="list-style-type: none"> Authority for the public drinking water supply program in HEALTH
RIGL 46-15 "Water Resources Board "	<ul style="list-style-type: none"> Assigns duties to the Water Resources Board. Provides authority to regulate the proper development, protection, conservation and use of water resources.
RIGL 46-15.7 "Management of the Withdrawal and Use of Water of the State"	<ul style="list-style-type: none"> Requires an inventory of water resources. Compilation of data.

2.0 Development of Environmental Indicators for Rhode Island

2.1 Introduction

An environmental indicator is defined as a “measurable feature of which singly or in combination provides managerially and scientifically useful evidence of ecosystem quality or reliable evidence of trends in quality” (ITFM, 1995). Indicators should have a firm basis in science but also be relevant to management needs and uses. Environmental indicators, when used appropriately, provide the means by which water quality management programs can successfully link management actions to environmental results. An important aim in this strategy is to enhance our ability to assess the effectiveness of water program actions by tracking environmental *outcomes* as measured by the information and indicators gained from adequate monitoring and assessment. Additional discussion concerning the concepts and principles important to indicator development is contained in MBI, 2003.

With respect to ambient monitoring, the ITFM outlined a framework in which indicators are used to link monitoring to management goals in water programs. They represent the key, essential chemical, physical and biological elements of water resource integrity (Karr et al, 1986) and reflect the most basic components of all ecosystems (living biota, habitat and primary water quality). As seen in Figure 1, the recommended indicators are categorized as either *core* or *supplemental* indicator. Core indicators include baseline biological (two assemblages of organisms), chemical, and physical parameters that should be measured everywhere - in all surface waters. Supplemental indicators are added depending on the assessment issues and questions that may arise for a waterbody that are not otherwise addressed by the core indicators. These largely reflect the particular uses of a waterbody, such as shellfishing, drinking water etc. as well as knowledge of past or present pollution sources. The EPA Elements guidance includes a list of recommended indicators similar to Figure 1. (EPA, 2003)

2.2 Partnership for Narragansett Bay (PNB) Ecological Indicators Process

In February 2003, the PNB working with the Coastal Institute conducted a two-day workshop geared at developing environmental indicators specifically tailored to Narragansett Bay and its watershed. The workshop culminated in a report entitled “Ecological Indicators for Narragansett Bay and its Watersheds” (Kleinschmidt, April 2003). The report presents an initial recommended core suite of *ecological* indicators designed for use in assessing the overall state of the Bay and its watersheds in order to answer questions such as are conditions getting better or worse over time? Developed with input from a variety of experts, the core indicators are intended to help in evaluating and communicating about the state of the Bay and its watersheds and will facilitate a more coordinated approach to long-term monitoring. The indicators fall into the following categories: Landscape composition and use; water and sediment quality; habitat conditions; and fish and wildlife populations and biodiversity. For each indicator, a more specific metric is identified to guide how the measure the indicator.

It is important to note that the Kleinschmidt report was broad in scope and addressed ecological issues in the Bay watershed beyond those pertaining to water quality. For the purposes of this monitoring strategy DEM has developed a subset of recommended ecological indicators that are directly related to field sampling of surface waters. DEM recognizes that from the perspective of watershed management, there are a number of additional environmental indicators relating primarily to land use and landscape condition that are useful to water resource programs. These include land use, forest cover, riparian buffer and impervious surface among others. The programs to collect these data are not discussed in this strategy but rather are expected to be a part of the broader environmental monitoring framework being developed via the RIEMC.

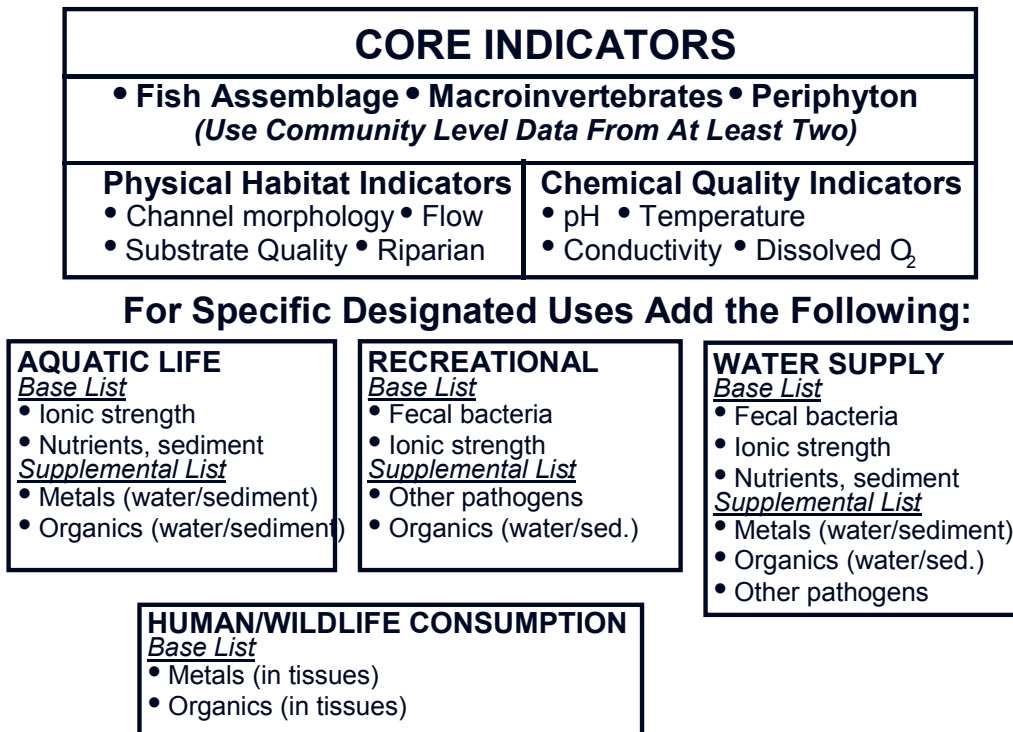


Figure 1. Core indicators and parameters by designated use to support an adequate watershed monitoring and assessment approach (after ITFM 1992 and Yoder 1998).

2.3 Recommended Environmental Indicators

The monitoring strategy has been developed to address the data needs required to support the use of the recommended indicators listed in Table 2A & B with respect to water quality monitoring. Table 2 was developed from the Kleinschmidt Report with consideration given to state legislation (RIGL 46-31-9(e), ITFM and EPA guidance. The strategy recommends specific monitoring programs for all water-related indicators specified in state law with the exception of aquatic nuisance plants and marine benthic organisms. DEM expects these indicators to be addressed in updates to the strategy. With respect to EPA guidance, all core indicators have been incorporated except those applicable to sediments. Strategies for monitoring sediments will also a future update to this strategy.

Many of the indicators can be easily linked to enforceable water quality standards. Accordingly, data collected to support measuring these indicators are an integral part of the DEM water quality assessment process. In other cases, the data collected for an indicator, such as abundance of plankton, may not be easily compared to a standard or benchmark. Such data may not be directly used in the water quality assessment process, but are needed to understand the functioning of aquatic ecosystems for purposes of effective protection and management. DEM expects further review and discussion of the selected indicators will be a basis for refining the indicator list and updating the monitoring strategy as needed.

A review of existing monitoring programs reveals that in many cases data are being collected to support the use of the recommended environmental indicators. The methods and protocols for sample collection and analysis are well developed and documented. With such indicators, primarily the physical and chemical parameters, the gaps in available data result from a lack of geographic coverage in data collection or insufficient frequency of sample collection. With other indicators, notably the marine biological indicators, there may be no widely accepted sampling approach for collecting data to support the indicator. Furthermore, even where data is collected, there may not be an established mechanism, such as the development of an index of biological integrity (IBI), that allows the data to be translated into meaningful information in the water quality assessment process. As a result, with respect to certain indicators, including biological assemblages in lakes and marine waters, there is need for further evaluation of how best to develop state monitoring and assessment capacity to address these indicators. With the exceptions of fish tissue analyses and fish assemblages, DEM has not specified new biological monitoring programs for the purpose of evaluating water quality. New biological monitoring strategies as part of the continuing development of the state's monitoring programs.

2.4 Recommended Program Enhancements – Environmental Indicators

- Via the monitoring collaborative, refine the list of recommended indicators applicable to the surface water monitoring strategy; e.g. biological indicators in lakes, coastal waters, etc. As needed, update the strategy to incorporate new indicators. – *In progress*
- Develop procedures to implement new criteria for dissolved oxygen in estuarine waters. Collaborate with EPA Technical Assistance Contractor to evaluate the best means for applying the criteria to existing data sets for Narragansett Bay. – *In progress*
- Develop a freshwater fish index of biological integrity (IBI) for rivers and streams, and possibly lakes, to allow application of existing and future data from fish surveys to contribute to water quality assessments. – *In progress*
- With respect to macroinvertebrate biological monitoring in wadeable streams, continue development of a reference condition approach to support use of the data in the water quality assessment process and development of tiered aquatic uses. – *In progress*
- Develop indicators on aquatic nuisance plants and application of such data in the water quality assessment process. This should be done in conjunction with establishing a lake management program within DEM that would further develop policies and strategies to manage aquatic weed problems, promote protection of lakes, support tracking of bioinvasive species and act as a liaison with URI-Watershed Watch (URI-WW) among other activities.
- Develop refined indicators to support drinking water assessments in collaboration with Department of Health (HEALTH).

Table 2A. Water Resource Environmental Indicators – Estuarine

Indicator – Estuary ^(a)	Metric	Specified in State Law (RIGL 46-31-9 (e))	EPA Indicator Status ^(b)	DEM Standards & Criteria (e)
Chemical and Physical				
Water Temperature	Mean Temperature	Yes	Core	Temperature increases/maximum addressed
Salinity	Freshwater influx	Yes	Core	-
Oxygen	Dissolved oxygen levels ^(c)	Yes	Core	Not less than 5-6 mg/l depending on class; (New criteria pending)
Nitrogen	Total nitrogen loading	Yes	Core	Total ammonia (mg/l)- numeric limits; Narrative criteria
Pathogens	Presence and concentration	Yes	Core	Fecal Coliforms - MPN/100 ml; Enterococci – pending
Metals	Presence and concentration	-	Supplemental for water column; Core for fish tissue(d)	Numeric criteria – dissolved metals; total iron Narrative rule; DEM/DOH policy applies for fish tissue
Organics	Presence and concentrations	-	Supplemental for water column; Core for fish tissue(d)	Numeric criteria Narrative rule; DEM/DOH policy applies for fish tissue
Total Suspended Solids	Mass and toxic concentrations	-	-	Turbidity (NTUs) Narrative criteria
Flows and Circulation	<ul style="list-style-type: none"> Freshwater inflow (time series) Groundwater inflow Bay circulation patterns Frequency of stratification 	Yes	Core - - -	Narrative rule governs acceptable minimum flows for rivers & streams
Biological				
Fish & Invertebrates	Assemblages and relative abundance across each bay habitat gradient Habitat assessment (benthic)	Assemblages and relative abundance-fish	Core biological indicator – use two assemblages with community level data	No biocriteria at present. Data not routinely used to assess water quality.
Shellfish	Assemblages and relative abundance across north/south habitat gradient	Assemblages and relative abundance – shellfish		
Benthic Organisms	Assemblages and relative abundance across north/south habitat gradient	Assemblages and relative abundance of benthic macroinvertebrates		
Chlorophyll	Chlorophyll per unit area	-	-	
Primary Production	Net Primary Production (NPP)	-	-	Data not routinely used to assess water quality.
Habitat Condition				
Coastal Wetlands	<ul style="list-style-type: none"> Acres of coastal wetlands by type and function Length of coastal wetland shoreline edge 	Land cover or uses within the shoreline buffer	-	Not applicable.
Benthic Habitats	<ul style="list-style-type: none"> Extent of submerged land substrate types; Acres of SAVs and patchiness 	-	-	Not applicable.

Table 2B Water Resource Environmental Indicators - Freshwaters

Indicator – Freshwaters (a)	Metric	Specified in State Law RIGL (46-31-9(e))	EPA Core Indicator (b)	DEM Standards & Criteria (e)
Chemical & Physical				
Water Temperature	Mean Temperature	Yes	Core	Temperature increases/maximum addressed
pH	pH in lakes and rivers	Yes	Core	6.5-9.0
Oxygen	Dissolved oxygen levels in lakes and rivers	Yes	Core	Numeric criteria
Conductivity			Core	-
Phosphorus	Total phosphorus concentrations	Yes	Core	Average total in lakes - .025 mg/l; narrative criteria
Nitrogen	Total nitrogen concentrations	Yes	Core	Total ammonia (mg/l)- numeric limits; Narrative criteria
Pathogens	Presence and concentration	Yes	Core	MPN/100 ml – coliforms Enterococci –pending
Metals	<ul style="list-style-type: none"> Presence and concentration Tissue analysis (c)	-	Core for water column & fish tissue (d) -	Numeric criteria – dissolved metals; Narrative rule; DEM/DOH policy applies for fish tissue
Organics (Volatile organic compounds, pesticides)	Presence and concentrations	-	Supplemental for water column; Core for fish tissue (d)	Numeric Criteria
Total Suspended Solids	Mass and toxic concentrations	-	-	Turbidity (NTUs)
Hydrology /Flow	<ul style="list-style-type: none"> Time series data Mean annual August monthly surface flows Groundwater flows 	Yes	Core -	Narrative rule applies; work underway to develop minimum stream flow standard
Water Clarity	Secchi depth		Core	
Biological				
Chlorophyll	<ul style="list-style-type: none"> Chlorophyll per unit area Lake eutrophication status 	-	-	- Lake trophic status is determined in assessment process
Primary Production	Net Primary Production (NPP)	-	-	-
Nuisance Plant Growth	To be developed	Yes	Core	Narrative rule applies; Excessive aquatic weed growth considered an observed effect
Fish & Invertebrates	Assemblages and relative abundance Habitat assessment Health of the organism	Assemblages and relative abundance-finfish	Core biological indicator – use two assemblages with community level data ; Supplemental	No biocriteria. Plan to develop tool (IBI) to use existing fish assemblage data in water quality assessment process
Macroinvertebrates	Assemblages and relative abundance	Assemblages and relative abundance of benthic macroinvertebrates	Core biological indicator – use two assemblages with community level data	No biocriteria. Existing policies on use of data in water quality assessment; currently relies on reference site approach. Work planned to develop reference condition approach.

Indicator – Freshwaters (a)	Metric	Specified in State Law RIGL (46-31-9(e))	EPA Core Indicator (b)	DEM Standards & Criteria (e)
Biological (cont'd)				
Reptiles and Amphibians	Assemblages and relative abundance across north/south habitat gradient Health of the organism		-	No biocriteria. Data not routinely used in water quality assessments.
Birds & Mammals	Assemblages and relative abundance across north/south habitat gradient Health of the organism		-	No biocriteria. Data not routinely used in water quality assessments.
Habitat Condition				
Anadromous Fish Habitat	Miles/acres of accessible suitable riverine spawning habitat			Not applicable.
Freshwater Wetlands	<ul style="list-style-type: none"> Acres of wetlands by type and function Length of freshwater wetland shoreline edge 	Land cover or uses within the shoreline buffer		Not applicable.
Forested lands	<ul style="list-style-type: none"> Extent of intact core habitat Acres of Forested land 			Not applicable.

(a) Indicators & Metrics adapted from Kleinschmidt August 2003.

(b) EPA Core Indicators: parameters recommended for measurement in all water quality sampling situations regardless of issue of concern; supplemental parameters are added to address specific use assessments or issues of concern. The only EPA recommended core indicator not included in the above listing is landscape condition.

(c) Two PNB sediment parameters have not been included in the current strategy : Redox Potential Discontinuity (RPD) depth as a measure of oxygen in sediments for estuaries; Concentration of Volatile Sulfide (AVS) as a measure of bioavailability of metals in sediments for freshwaters. Sediment monitoring will be a future revision of the strategy.

(d) EPA recommends mercury, chlordane, DDT and PCBs be included in fish tissue analysis.

(e) Last column indicates if the metric is reflected in current DEM Water Quality Regulations(August 6, 2000)

3.0 Agency Roles and State Water Quality Program Information Needs

3.1 Overview of Agency Roles

There are numerous agencies and organizations carrying out monitoring activities in Rhode Island waters at the local, state and federal level. Figure 2 provides an illustration of the most active organizations. The state, primarily through DEM, and its partnerships with URI, carries out the function of ambient monitoring as reflected in both water quality and fishery management programs. State agencies also conduct a variety of program specific monitoring activities. The federal agencies serve as important partners, but with the exception of USGS, their focus is primarily research and special projects or regional programs conducted in connection with federal agency missions. At the local level, a variety of groups, as well as individual volunteers are involved in monitoring. When considering the data needs of state resource managers, it's important to note that while some programs outside state government produce useful information for resource managers, not all monitoring is intended for this purpose. In many cases, the data produced from monitoring conducted for research or educational purposes may not be relevant or beneficial to state management programs. This section focuses on those programs that produce data of sufficient documented quality and quantity so as to be used by state resource managers. The following section outlines the current roles of agencies and organizations involved in monitoring in Rhode Island and identifies the key data needs of state water resource programs.

3.2 Coordination of Monitoring & RI Environmental Monitoring Collaborative

With federal, state, local entities, non-profits organizations, academic institutions and others engaged in monitoring, the issue of coordination is important. Recent reviews of monitoring found overall coordination was lacking in RI and that a mechanism was needed to strengthen coordination, facilitate collaboration and enhance monitoring programs in general.

The new RI Environmental Monitoring Collaborative provides an appropriate forum for making improvements in coordination and encouraging collaboration among various monitoring activities. It has developed principles intended to guide monitoring programs that emphasize making data broadly available. The RIEMC formed and began meeting in August 2004. As described in Section 1.6, the RIEMC is charged with developing a comprehensive environmental monitoring plan broader in scope than this strategy which is limited to water monitoring. As a first step in this process, the RIEMC updated the inventory of monitoring programs developed via the PNB process. The group issued its first report to the RI Bays, Rivers and Watersheds Coordination Team in January 2005. (RIEMC, 2005)

The RIEMC report notes that development of a truly comprehensive environmental monitoring program will occur over time. The following topic areas, all related to management concerns within state water programs, may require the development of additional monitoring strategies in order to provide state managers with needed data. In many cases, past and present monitoring activities have provided some data and experience from which to devise appropriate long-term monitoring approaches.

- Mapping benthic habitat in coastal waters.
- Periodically measuring the extent of submerged aquatic vegetation (SAVs).
- Long-term strategy for monitoring bioinvasives in coastal waters.
- Monitoring phytoplankton (primary productivity) in coastal waters.
- Monitoring zooplankton in coastal waters.
- Assessing fish tissue contamination in coastal waters.
- Monitoring the extent of nuisance aquatic weeds in lakes and ponds.
- Long-term strategy for monitoring bioinvasives in freshwaters.
- Nutrient criteria development in freshwaters and coastal waters.
- Measuring sediment quality.

- Bioassessment of coastal and freshwater wetlands.
- Assessing groundwater quality
- Emerging pollutants of concern; e.g. pharmaceuticals

The RIEMC also report identifies a need to provide staffing support for its operation to enhance its effectiveness. While the RIEMC focuses on facilitating coordination, the implementation of monitoring programs; e.g. field sampling activities, is accomplished within its participating agencies, both statutory members and others. The report and principles are available at www.ci.uri.edu/Projects/RI-Monitoring.

In reviewing monitoring among state agencies, DEM concluded that while a lack of coordination was not causing a duplication of effort in monitoring programs, it was preventing data from being used to its maximum benefit. Due to its function of assessing water quality data, the DEM-OWR is generally aware of the on-going monitoring programs, as well as special projects that generate water quality data, being undertaken by others within state government. Steps have been taken in recent years to improve the transfer of data between the DEM-OWR and other state programs that generate data.

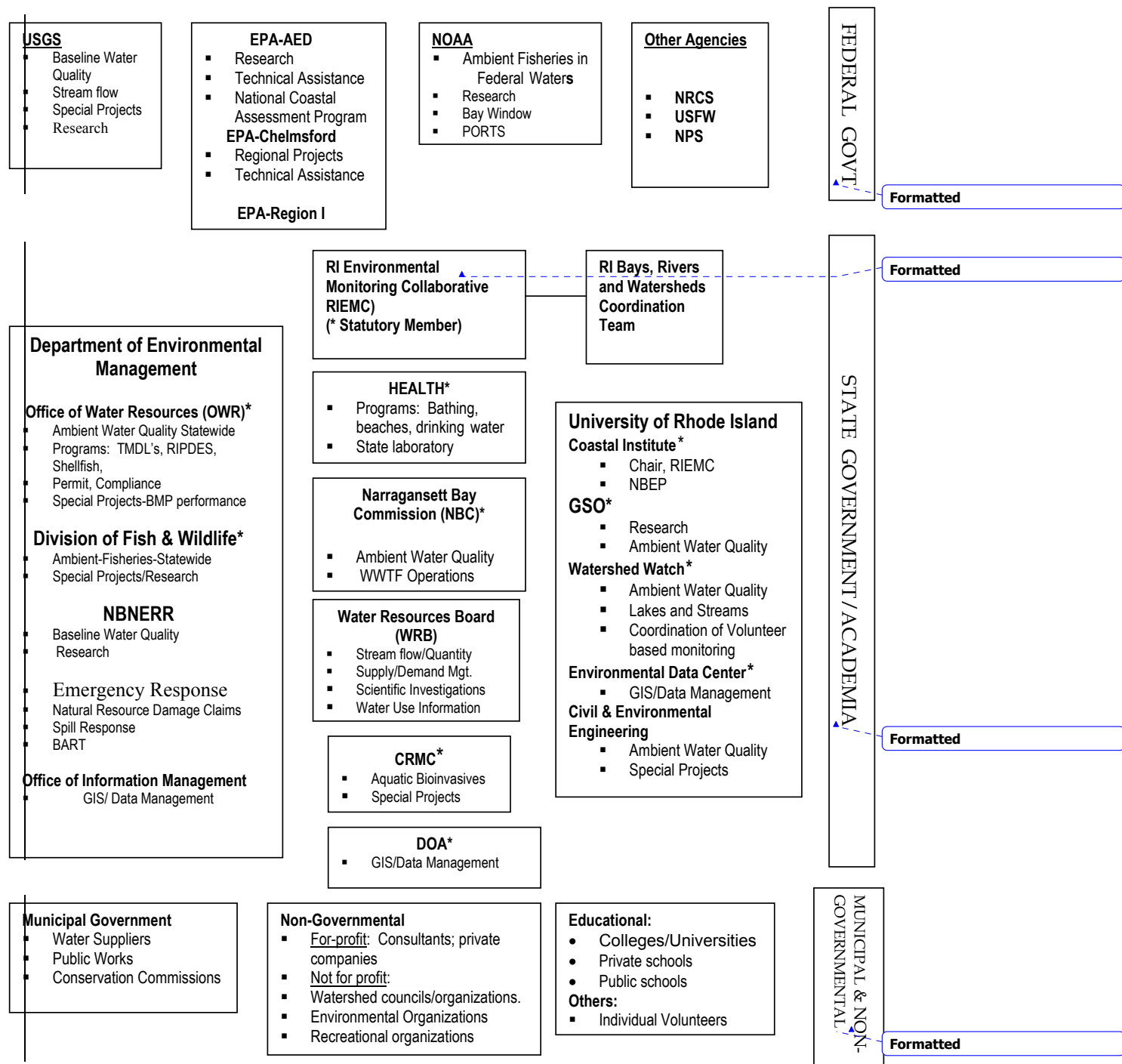
With respect to the larger universe of monitoring programs that involve the federal government, local agencies, non-profits, academic institutions and the private sector, the lack of effective coordination is an obstacle to making the best use of pertinent data within state water resource programs. State managers may not be aware of all the monitoring work being undertaken in RI waters, despite certain mechanisms such as serving on advisory committees (e.g. Sea Grant, Bay Window, etc.) and the joint planning process envisioned by the EPA Performance Partnership Agreement (PPA). The access to data generated outside of state programs varies widely from being readily available to not easily accessible.

There is also a need to improve coordination with neighboring states on data collection in watersheds that extend across state boundaries. In some watersheds, such as the Blackstone River Watershed, committees with representation from both states, have provided a mechanism to facilitate coordination. In most cases, the committees have formed around a specific project or objective and do not function as long-term, permanent structures. Recently, representatives of the Governors from both Massachusetts and Rhode Island have met to begin to address interstate issues related to the management of the Narragansett Bay watershed. It is expected that further discussions will lead to written memorandums of agreement that will reinforce effective coordination on interstate issues.

3.3 State Agencies and Organizations

The state agencies and entities with important roles in monitoring include: DEM, HEALTH, URI, Water Resources Board (WRB) and Narragansett Bay Commission (NBC). Their roles are summarized in Table 3, which also identifies the involvement of other state agencies. A listing of state agency involvement in specific monitoring programs is included in Appendix C. The list distinguishes between ambient monitoring which measures water quality for the purpose of determining its condition on an on-going basis and program specific monitoring which is designed to collect data for a narrower purpose or limited duration of time; e.g. TMDL study, wastewater treatment facility (WWTF) effluent monitoring. The roles of the key agencies are further described in this following subsections.

Figure 2. Organization of Water Monitoring Programs



Department of Environmental Management (DEM)

Among state agencies, DEM has the most wide-ranging role in water monitoring and is responsible for reporting to EPA as federally mandated on the condition of the state's water resources. It conducts numerous monitoring programs including those designed for water quality, water pollution control, fisheries management and emergency response purposes.

DEM-Office of Water Resources (DEM-OWR)

The DEM-OWR conducts both ambient and programmatic monitoring programs. With respect to ambient monitoring, the DEM-OWR has involvement statewide in both fresh and coastal waters and the agency responsible for reporting on water quality conditions to EPA pursuant to the federal Clean Water Act. DEM-OWR currently has limited internal capacity to carry out ambient monitoring and as a result has facilitated the collection of data (physical, chemical and biological) by funding contracts and cooperative agreements. Current contracts support lake monitoring by the URI-Watershed Watch (URI-WW) Program, ambient monitoring of rivers (water chemistry) by URI-Civil and Environmental Engineering Department (URI-CEE) and biological (macroinvertebrate) monitoring of Wadeable Rivers and streams by a contractor, currently ESS Group. In addition, since 2004 the DEM-OWR has provided support to sustain fixed-site monitoring stations in Narragansett Bay via agreements with URI-Graduate School of Oceanography (URI-GSO). DEM-OWR also supports stream flow gage measurements via an agreement with USGS. The use of ambient data in the water quality assessment process is detailed in Section 3.6.

The DEM-OWR also conducts program-specific monitoring activities including targeted water quality investigations of impaired waters, known as Total Maximum Daily Load (TMDLs), bacteriological monitoring of shellfish growing areas and effluent monitoring of wastewater discharges. TMDLs consist of targeted water quality investigations that identify pollution sources and recommend actions to control or eliminate sources in order to return water quality to acceptable conditions. The investigations usually involve an intensive sampling design with monitoring locations concentrated within a geographic area and targeted to isolate specific sources of pollution, e.g. individual storm drains. In some cases, the water quality restoration plan is based on application of a water quality model that is used to calculate acceptable pollutant loadings. Models that have been used successfully include WASP and QUAL2. In the TMDL program, DEM both conducts monitoring and contracts for monitoring as part of implementing projects.

In the shellfish growing area program, DEM maintains two boats to monitor 17 shellfish growing areas. In 2003, the program collected over 2,000 samples from 303 stations in coastal waters. In the wastewater program, the monitoring of discharges is primarily carried out by the permittee with DEM-OWR oversight. DEM may collect samples on an as needed basis as part of compliance inspections. DEM also collects annual effluent samples from major dischargers for toxicity testing as part of a program known as the Sherlock Program. In the above programs, while DEM staff are engaged in collecting samples, the analyses of samples is performed by outside laboratories, including the DOH laboratory, certain URI laboratories as well as private laboratories secured through state master price agreements. Housed in the DEM headquarters in Providence, DEM-OWR currently lacks any laboratory space of its own and has insufficient space to properly store and maintain sampling equipment expected to be acquired in the coming year.

DEM- Division of Fish & Wildlife (DEM-F&W)

The DEM Division of Fish & Wildlife has for decades been involved in monitoring the abundance of aquatic biological resources. Surveys to support both freshwater and marine fisheries management programs continue to be a major focus within the DEM-F&W. The surveys are designed to count the populations of various organisms, and include to varying degrees measurements of water quality parameters including temperature.

The Marine Fisheries Section has monitored the abundance of finfish, crustaceans and invertebrates (shellfish) since 1979. It carries out over a dozen different survey programs that employ bottom trawls, seine and gill nets, and dredge techniques to collect organisms as part of the long-term baseline monitoring of the fisheries resources. Finfish trawls are designed to generate data that is compatible with monitoring conducted by the NOAA- National

Table 3. Roles of State Agencies and Organizations in Surface Water Monitoring

Department of Environmental Management – Major role in monitoring with involvement in water quality, water pollution control and fisheries management programs.	
Office of Water Resources	<ul style="list-style-type: none"> Assesses and reports on water quality conditions statewide; Prepares reports in water quality conditions mandates by federal Clean Water Act; e.g. 303(d), 305(b) Designated state water pollution control agency; serves on the RIEMC; Limited baseline monitoring activities conducted by staff; currently relies heavily on outside contracts; Participates in fixed-station network in Narragansett Bay; Conducts TMDL water quality investigations via staff and contractual services; Conducts short-term targeted monitoring studies for various purposes; Supports a cost-sharing agreement with USGS for measurement of flow at stream gages; Utilizes outside laboratory services (including HEALTH and private vendors) for analytical work; Program specific monitoring: Shellfish growing areas, RIPDES effluent monitoring; BMP performance monitoring, permit compliance Maintains several databases to support Office functions; Makes extensive use of GIS in water programs Participates in BART (See Emergency Response); Regularly reviews data as part of pre-screening for significant low oxygen conditions in the upper bay; Participates in the Bay Window program
Division of Fish & Wildlife	<ul style="list-style-type: none"> Lead agency for fisheries management in state waters – both freshwater & marine; Serves on the RIEMC; Conducts long-term fisheries surveys and supports other related fisheries monitoring programs; Collects some water quality data as a routine part of fisheries monitoring programs; Maintains various databases to support its programs; Investigates fish kill events; Participates in BART (See Emergency Response) including public outreach; Participates in the Bay Window Program;
Narragansett Bay National Estuarine Research Reserve (NBNERR)	<ul style="list-style-type: none"> Maintains fixed-stations in the network in Narragansett Bay; reports data to NOAA National Estuary Reserve Program and shares data with DEM and others. Compiling data from the entire fixed station network for 2004; maintains databases. Participates in Bay Window Program May conduct research related to Narragansett Bay Estuary.
Office of Compliance & Inspection	<ul style="list-style-type: none"> May collect data in the course of investigating water pollution complaints including assisting HEALTH on beach closure investigations; Participates in BART
Emergency Response	<ul style="list-style-type: none"> Coordinates the Bay Assessment and Response Team (BART). Coordinates monitoring in the event of major spills or fish kills, including accessing outside expertise as needed; May collect data as part of oil and hazardous material spill clean-ups; Natural resource damage claims.
Office of Waste Management	<ul style="list-style-type: none"> Receives water quality data in various site assessment and remediation reports; Maintains data systems to support program functions;
Office of Information Management	<ul style="list-style-type: none"> Provides GIS services to other DEM offices and divisions; Central computer support/network maintenance within DEM.
Department of Health – Conducts monitoring for program-specific purposes and operates the state laboratory	
Office of Food Protection	<ul style="list-style-type: none"> Bathing beach monitoring program including investigating beach closures; Serves as HEALTH representative on the RIEMC; Maintain database to support program functions; Participates in BART
Division of Drinking Water Quality	<ul style="list-style-type: none"> Public Drinking Water Supply Program – monitoring requirements for water suppliers include sampling in drinking water reservoirs; Maintains database to support program functions;
State Laboratory	<ul style="list-style-type: none"> Provides laboratory services
Office of Environmental Risk Assessment	<ul style="list-style-type: none"> Reviews fish tissue data and issues fish consumption health advisories

Table 3 continued

Water Resources Board	<ul style="list-style-type: none"> • Supports a cost-sharing agreement with USGS for measurement of flow at stream gages; • Developed a plan with partners for expanding the gage network in RI; • Coordinates the RI Rivers Council (per recent legislation) which has previously distributed funds to support volunteer-based monitoring by watershed organizations; • Contracting for basin studies to support programs and policy development. • Administers Drought Management Program; • Supply management; demand management; • RIEMC participating agency • Data management; database development
Narragansett Bay Commission	<ul style="list-style-type: none"> • RI's largest wastewater treatment system. • Conducts monitoring to support operation of the WWTF and collection system. • Conducts regional monitoring in receiving waters and rivers affected by CSOs. • Maintains fixed stations in Providence and Seekonk Rivers (part of the network in the Bay). • Will resume baseline monitoring of the Providence and Seekonk Rivers in spring 2005. • Serves on the RIEMC. • Supports special monitoring projects; • Operates its own laboratory. • Maintains a web-site that provides access to data.
Coastal Resources Management Council	<ul style="list-style-type: none"> • Participates in periodic surveys of bioinvasive species in marine waters • Developing a management plan for aquatic bioinvasives. • Serves on the RIEMC.
Department of Transportation	<ul style="list-style-type: none"> • Funds monitoring work to evaluate the effectiveness of stormwater best management practices (BMPs) ; e.g. constructed stormwater treatment
Department of Administration	<ul style="list-style-type: none"> • Administers central GIS services and maintains data layers for use by state agencies. • Develops updated or new data layers. • Oversight and coordination of information management services for all state agencies. • Serves on the RIEMC.

University of Rhode Island	
Graduate School of Oceanography (GSO)	<ul style="list-style-type: none"> • Conducts research that involves both long-term and short-term monitoring in coastal waters. • Participates in the Bay Window Program. • Maintains fixed –site stations as part of the network in the Bay. • Serves on the RIEMC.
Coastal Institute	<ul style="list-style-type: none"> • Chairs the RIEMC; • Sponsors and maintains a website (www.narrbay.org) aimed at providing access to data on the Bay and its watershed; • Participates in the Bay Window Program.
Narragansett Bay Estuary Program (Administered by URI-CI in cooperation with DEM)	<ul style="list-style-type: none"> • Participates in the on-going development of Bay monitoring programs; • Provides technical advice and participates in BART; • Participates in DEM water quality assessment process for coastal waters; • Participates in Bay Window Program; • Conducts and assists others in targeted monitoring studies; • Data synthesis and dissemination concerning Bay conditions. • Reports on the status and trends in Bay conditions. • RIEMC participating program.
Cooperative Extension	<ul style="list-style-type: none"> • Administers the URI-Watershed Watch Program; • Serves on the RIEMC.
Civil and Environmental Engineering Dept.	<ul style="list-style-type: none"> • Baseline monitoring of rivers and streams via agreement with DEM. • Special studies.
Environmental Data Center	<ul style="list-style-type: none"> • Provides central GIS services to the University. • Provides technical support services to the DOA- GIS Program. • Helps develop new data layers and GIS applications. • Serves on the RIEMC.

Marine Fisheries Service (NMFS) in federal waters and that can be used to support regional fisheries management decision-making. The Section also implements and funds additional monitoring programs, including research, which reflect specific management concerns; e.g. lobster shell disease and maturity status. The Section is based at Fort Wetherill, a new facility opened in April 2002 that includes laboratory space. It recently acquired the *R.V. John H. Chafee*, a new 50-foot length vessel used for trawls in the Bay and Rhode Island coastal waters.

The Freshwater Fisheries Section has used electrofishing methods to survey fish populations in rivers, streams, lakes and ponds across the state over the last ten years. Work underway to publish the data is estimated for completion in 2006. Work is also conducted to support the anadromous fish program. The Section has developed a collection of fish specimens and conducts its work from the Great Swamp Management Area. The facilities there are currently cramped and antiquated with respect to the Section's needs. A new facility, with modern laboratory space, is in the preliminary design stage.

Other DEM Divisions involved with water monitoring are noted in Table 3.

Department of Health (HEALTH)

HEALTH administers two programs routinely involved with monitoring: bathing beach and public drinking water supply. Both programs are important sources of data for the DEM water quality assessment process with respect to determining whether drinking water and recreational uses of surface waters are being supported. The HEALTH Bathing Beach Program ensures that all 118 licensed beaches in the state are sampled for pathogens. In 2003, a total of 2,567 samples were collected, a significant increase over prior years attributed in part to improved capacity within the state program enabled by federal grants. (RI HEALTH, 2003) The HEALTH Division of Drinking Water Quality (DWQ) administers and enforces the federal Safe Drinking Water requirements for monitoring with respect to drinking water supplies. This includes collection of data from the raw water source; e.g. terminal reservoir. DWQ participates in the DEM assessment process with regard to evaluating use support for waters designated as drinking water supplies, which includes reservoirs and their tributary streams.

HEALTH also operates the state laboratory which is used by HEALTH programs and some of DEM's programs. The Laboratory has a Biological Sciences Section and an Environmental Science Section that conduct various water analyses. The HEALTH laboratory is the only facility in the state approved for use by the DEM Shellfish Program. With respect to water monitoring, HEALTH has the instrumentation to analyze for most, but not all, of the chemical parameters required in this strategy. For example, the Laboratory currently does not analyze for metals and phosphorus to detection limits sufficiently low to meet DEM's data needs. Analysis for certain compounds not routinely monitored, such as dioxin, requires specialized capability that does not presently exist in any laboratory in the state.

RI Water Resources Board (WRB)

The RI WRB has broad authority in planning, developing and managing public water supplies. The Board is charged with managing the proper development, protection, use and conservation of water resources. Its primary responsibility is to ensure that sufficient water supply is available for present and future generations. The supports monitoring work conducted by other entities. The agency has for many years been supporting on-going monitoring of stream gages to measure flow via a cooperative agreement with the federal United States Geological Survey (USGS). RIWRB is also currently funding studies of water use and availability that will eventually cover nine basins. In 2004, state legislation transferred the RI Rivers Council into the RIWRB from the Department of Administration (DOA). The RI Rivers Council does not conduct monitoring, but has in the past provided state funding to local watershed organizations in the form of small grants to build their capacity to engage in monitoring at the local level.

Narragansett Bay Commission (NBC)

At the regional level, the Narragansett Bay Commission (NBC) has made a significant commitment to monitoring not only to support their wastewater treatment system operations but also to assess and track the conditions in rivers and

coastal waters that are part of the watersheds within their service area. They have an established section within their organization that is devoted to monitoring. In addition to meeting significant monitoring needs within the WWTFs, the section conducts regional fecal bacteria monitoring in four freshwater rivers as well as the estuarine Providence River, and participates in the fixed-station monitoring network for Narragansett Bay by operating stations in the Providence and Seekonk Rivers. NBC has conducted various monitoring studies including work to characterize background conditions for dissolved metals, nutrients and circulation in the Providence, Seekonk and Ten Mile Rivers (2001-2002) and monitoring to support TMDL development in the Woonasquatucket River (2001-2002). NBC plans to resume monitoring of ambient water chemistry in the Providence and Seekonk Rivers in the spring of 2005. It operates a laboratory to support their programs and WWTF operations. NBC also maintains a website that describes their monitoring activities and provides access to data. (www.narrabay.com)

University of Rhode Island (URI)

The University of Rhode Island plays a variety of roles with respect to monitoring including collection of baseline data, research, data synthesis and dissemination. The URI Coastal Institute (URI-CI) is coordinating the newly formed Rhode Island Environmental Monitoring Collaborative and houses the Narragansett Bay Estuary Program. Several URI programs support the function of baseline monitoring including the URI- Watershed Watch (URI-WW) Program, a sizable volunteer-based monitoring effort that is active not only in lakes but also tributary streams and selected coastal waters, and the Civil and Environmental Engineering Department that has conducted water chemistry monitoring in river and streams for over ten years. URI-Graduate School of Oceanography (URI-GSO) has also been a participant in the fixed-site monitoring network deployed in Narragansett Bay since its inception. These programs all operate their own laboratory facilities. DEM routinely uses data from these programs and provides them with financial support.

With respect to research, URI personnel carry out both short and long-term monitoring programs in RI waters. Research in Narragansett Bay generating long-term data sets of particular interest to the state include: URI-GSO fish trawls, URI-GSO benthic community monitoring, and phytoplankton monitoring. The short-term research projects are too numerous to specify in this strategy, but many have supported state resource programs including MERL nutrient enrichment experiments. URI-GSO and its collaborators was recently awarded a NOAA grant to research hypoxia in Narragansett Bay over the next five years. URI administers the Sea Grant Program that continues to be an important source of funding for research. Depending on the research project, data generated by researchers may be made available to state resource managers routinely or upon request. Some data may not be shared until publication, which may be years following initial data collection.

Regarding data management, in addition to activities conducted by individual programs or researchers, URI operates the Environmental Data Center (EDC) which provides technical support to the state's Geographic Information System (GIS) as well as undertaking various projects on its own. Via the Bay Window Program, which has provided NOAA funding to Rhode Island to enhance monitoring and support critical research for Bay management, the URI-CI was able to create a web-site, www.narrabay.org, that serves as a portal to selected datasets on Narragansett Bay and its watershed. The intent is to bring different sources of data together to encourage data synthesis and integration. It also links to other websites maintained by DEM and NBC among others. Various URI programs, including Sea Grant, are also routinely involved in publishing reports as part of an on-going public outreach function.

3.4 Federal Agencies

As mentioned above, much of the federal agency monitoring conducted within RI is geared toward research and program needs of the agencies. The federal agencies engaged in monitoring in RI include (1) the United States Geological Survey (USGS), (2) the Environmental Protection Agency (EPA) – Atlantic Ecology Division (AED) based in Narragansett and the Regional Laboratory (Chelmsford, MA) and the (3) National Oceanic and Atmospheric Administration (NOAA). Regarding coastal waters, both EPA and NOAA are engaged in various research projects, selections of which are listed in Appendix D. Among them, the EPA-AED National Coastal Assessment (NCA)

program, an EPA Environmental Monitoring and Assessment (EMAP) research initiative, has collected data from locations in Narragansett Bay as part of a larger regional and national coastal monitoring program. NCA uses a probabilistic design and involves measurement of water column parameters, sediment chemistry and toxicity, benthic communities, demersal fish and tissue contamination. Data were collected originally from 20-35 stations in 2000-2001 and followed up with sampling from 20 stations in 2003-2004.

Within NOAA, two divisions are involved in monitoring: the National Marine Fisheries Service (NMFS) and the National Ocean Service (NOS). NOAA- NMFS, as part of the Bay Window Program, has conducted monthly trawls in the main channels of Narragansett Bay, Mt. Hope Bay and the Providence River using a towed device (Nu-shuttle) as part of research into the cycle of productivity in the Bay. While the voluminous data has not yet been integrated with state programs, data synthesis is planned and steps are being taken by DEM-OWR to assess its applicability to the state water quality assessment. NOS provides measurements of tides and currents.

Within freshwaters, the USGS has the longest involvement in the state given its institutional role of monitoring the nation's waters. It has a lengthy history of partnering with the state on baseline monitoring activities and the data is widely used and relied upon in state programs. The first stream gage station dates to 1914. USGS first entered into agreement with the State of Rhode Island in 1939 and the gage network expanded to ten sites. (Campbell, J., personal communication 2004). The network of continuous gages currently consists of 19 stations – all maintained by USGS with a contribution of state funding providing a cost-share for 16 stations. Baseline water quality data started to be collected more consistently in the 1970s coinciding with initial implementation of the Clean Water Act. USGS also carries out applied research and special projects in which shorter-term monitoring is conducted. USGS maintains an office in Providence and web-site that provides access to data.

3.5 Private and Local Organizations

As reflected in the Monitoring Program database, there are a variety of local entities engaged in on-going monitoring. These include other academic institutions (Brown U., Roger Williams U.), watershed organizations, nonprofits (e.g. RI Natural History Survey, Save The Bay, Trout Unlimited, etc.) as well as neighborhood groups, lake associations which may consist of solely volunteers. Additionally, within municipal government, conservation commissions, water suppliers and public works departments as well as schools may be involved. The type of monitoring conducted by local entities varies widely and ranges from the professional work conducted by scientists in organizations such as the RI Natural History Survey and RI Audubon to school-based projects designed for educational purposes. Many of the monitoring programs or activities being carried out at the local level are not designed for the purpose of supporting the state resource management programs, but rather may have a primary purpose of educating or raising awareness. Regardless, DEM encourages data to be shared with the state and depending on the quantity and quality of such data, will make use of it within the assessment process in accordance with the policies reflected in DEM's Consolidated Assessment and Listing Methodology (CALM) document, currently being drafted. It should be noted that those local entities monitoring under the umbrella of the URI-WW program, which provides professional oversight and quality assurance, produce data that is routinely used by the DEM-OWR. Additionally, regional volunteer-based monitoring in the Blackstone River Watershed, organized by the Blackstone River Coalition, is being conducted with professional oversight, in part provided via the John H. Chafee Blackstone River Valley National Heritage Corridor Commission, and in accordance with an EPA and DEM approved quality assurance plan.

3.6 Water Quality Standards and Assessment Process

The following provides additional detail on the DEM water quality assessment process that applies to all Rhode Island surface waters. It explains how monitoring data from a variety of sources is integrated by the DEM-OWR to reach conclusions regarding the quality of the state's water resources. This process is the basis for a majority of water pollution abatement actions undertaken in RI, and is fundamental to watershed-based environmental protection. Figure 3 provides an illustration of the process.

Water Quality Standards

DEM promulgates the water quality standards (WQS) that establish minimum water quality requirements for all surface waters of Rhode Island. The purpose of WQS are to protect public health and welfare and to enhance, improve and maintain water quality as provided under the laws of Rhode Island and the Clean Water Act. The Rhode Island WQS consist of designated uses of the waterbody and chemical and physical criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses.

Designated Aquatic Life Uses

In the Rhode Island Water Quality Regulations all surface waters of the state are designated to support fish and wildlife habitat, which is interpreted as *Aquatic Life Use*. Currently, this general use category has not been divided into specific subcategories or tiers which identify different levels of protection. A number of states have defined subcategories of Aquatic Life Use based on a range of aquatic community types which may include descriptions of core aquatic species representative of each subcategory (e.g., cold water fishery, warm water fishery). An advantage to defining tiered Aquatic Life Uses is the ability to establish greater precision in applying protection. Data to create tiered Aquatic Life Uses need to be collected to support their development.

Biological assessments have been a fundamental component of State and Tribal water quality monitoring and assessment programs for more than three decades. However, it is only during the past 13 years that U.S. EPA has formally adopted guidelines and policies pertaining to the role of biological assessments and biological criteria in State and Tribal water quality management programs including water quality standards (WQS). Some States and Tribes have moved forward to formally adopt narrative and in some cases numeric biological criteria. Biological criteria are to be used in concert with chemical/physical and other stressor/exposure indicators to develop an understanding of key limiting factors and their orders of importance. This is essential to determining the severity and extent of impairments and threats and in determining what abatement and restoration measures are most appropriate in a given situation. Biological data provide important insights into associated causes and sources of stress; however, this is achievable only with a sufficiently detailed biological assessment.

Non-Aquatic Life Uses

The waters of the state are also designated for the following non-aquatic life uses: *recreation, fish consumption, drinking water supply, and shellfishing*. In the Rhode Island Water Quality Regulations, all surface waters of the state are designated for recreation and fish consumption uses and subsets of waters are designated for drinking water supply or shellfishing/shellfish consumption use. In Rhode Island, recreation use includes both primary (e.g., swimming, surfing) and secondary (e.g., boating and fishing) contact uses. Some states have defined tiered recreational uses in their water quality standards. EPA is currently developing a national policy on this issue for state's to use as guidance in designating appropriate recreational uses. Data may need to be collected to apply this policy in Rhode Island. All waters of the state are designated to support fish free from contamination that could pose a human health risk to consumers (fish consumption use). The primary public health concerns are those waters that produce fish of edible sizes. Currently the state has limited monitoring data to evaluate this designated use.

A subset of freshwaters is designated as a source of public drinking water supply. DEM, in collaboration with the DOH-DWQ, is refining the approach used to assess support for the drinking water use. While data on raw water quality is available from terminal drinking water reservoirs, in most cases there is no routine sampling in the remainder of water supply watersheds (upgradient reservoirs, tributary streams etc.). Additional data collection is warranted.

Finally, a subset of saltwaters (Class SA and SA{b} waters) are designated for shellfish harvesting for direct consumption. Extensive bacteriological data is collected to assess this use consistent with the National Shellfish Sanitation Program requirements. Additionally, other data, including chemical data, may be used in determining shellfish designations.

Assessment Process

As required by the EPA, DEM-OWR administers an on-going program to assess and report on water quality conditions. This is done by evaluating whether the criteria established to protect designated uses of a waterbody are being met. The policies and procedures that govern the assessment process are documented in the Consolidated Assessment and Listing Methodology (CALM) currently being drafted by DEM. To begin the process, DEM-OWR solicits and compiles data from all available sources. This includes advertising a request for data prior to conducting assessments via the press and DEM web-site, as well as sending letters to over 100 potential data generators (local entities, etc.) This includes compiling data from the major on-going monitoring programs, most of which have contractual relationships with the DEM-OWR as well other sources including water suppliers, local watershed groups and researchers. If valid data are available to make such a judgement, then the waterbody is assessed and a determination is made as to whether the waterbody fully supports its uses or is in some manner impaired (polluted or altered). Conversely, if data are lacking, the waterbody is categorized as *unassessed*. In the past, given data availability, it was possible and fairly common for a waterbody to be assessed for one particular use (e.g. recreation) and not another (e.g. aquatic life). As a result, the percentage of waterbody types (lakes, rivers and estuarine) assessed for certain uses would vary as indicated in Table 4.

In general, an assessment decision is an indication that there is data available to characterize the specific waterbody for a designated use. However, the process does involve a limited amount of extrapolation of data in accordance with the CALM. This means data collected in one waterbody may be extrapolated as representative of another. This occurs within in the context of rivers and their tributaries. A station on a river may be deemed representative of upstream conditions in tributary streams. DEM-OWR makes assessment decisions following meetings of relevant state agency staff who review and weigh the available data, consider other information such as precipitation, etc. which may affect the representativeness of the data, apply the CALM and reach consensus on the interpretation of the data for assessment purposes. Assessment results are compiled and reported to EPA and made available to the public on DEM website. The assessment process is conducted every two years with additional reporting in the off-year of any substantial changes due to new data.

Table 4. Percent of Waterbody Type Assessed for Specific Uses

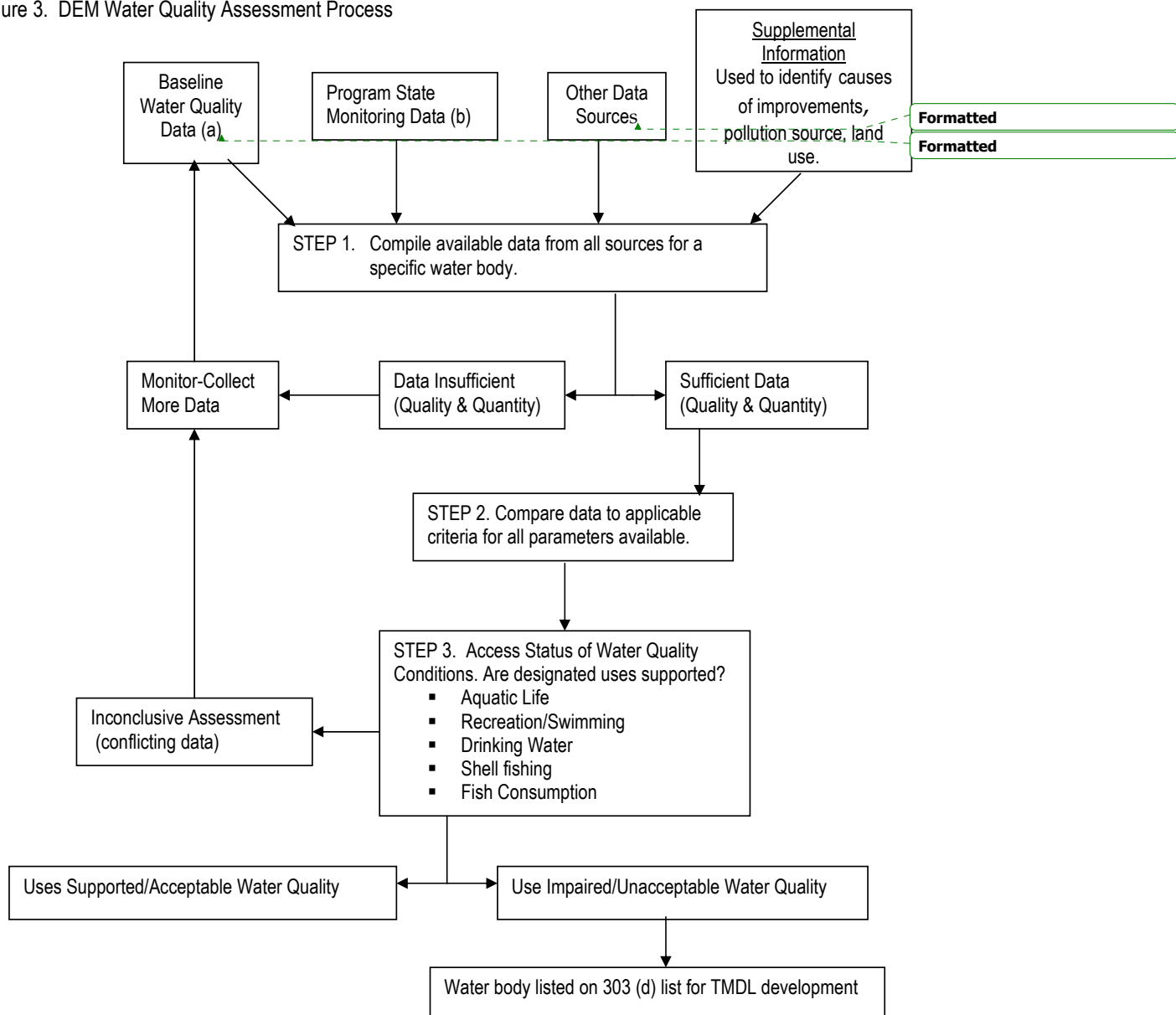
Designated Use	Rivers & Streams	Lakes & Ponds	Estuaries
Aquatic Life	36%	75%	75%
Recreation/Swimming	31%	70%	99.6%
Fish Consumption	<1%	2%	0

Source: RI DEM 2004 305(b) Report

As state assessment results were compiled and reported nationally, concerns arose about the inadequacies of the available data and about consistency with the assessment process among states. Subsequently, EPA issued new guidance that affects all future reporting and will dramatically impact the percentage of waters reported as assessed. EPA is requiring that for a waterbody to be considered assessed, all designated uses for that particular waterbody will have to be evaluated. In Rhode Island, the combination of all waters being designated for fish consumption and the absence of a program to assess fish tissue contamination will result in the percentage of waters categorized as fully assessed being very low in the next reporting cycle in 2006. Further investment in this area is needed if Rhode Island is going to be able to achieve the goal of comprehensively assessing its surface waters.

To assess a waterbody, a determination is made as to whether the water quality conditions support the designated uses or whether one or more of the uses are in some manner impaired due to pollution or other forms of degradation (hydrologic modifications). Those waterbodies determined to be impaired are compiled in a list, known as the 303(d) list, and then scheduled for future water quality studies, known as water quality restoration plans or TMDLs. Due to the importance of the listing decisions, including the legal and cost implications, there is an increased focus on the quality assurance of data relied upon to make such decisions.

Figure 3. DEM Water Quality Assessment Process



- a) Data includes physical, chemical and biological measurements.
b) Programs that are key sources of data: Shellfish, Bathing Beaches, Drinking Water

DEM currently has 137 waterbodies listed on its 2004 303(d) list with an associated TMDL schedule that extends to 2012 (RIDEM, 2004). Improving baseline monitoring and assessment is important to insure that water quality impairments are systematically and accurately identified and that the TMDL list is developed and prioritized accordingly. Without adequate data on water quality conditions statewide, existing pollution problems may fail to be identified and given proper attention. Compared with current practice, improved ambient monitoring should also facilitate the completion of water quality restoration plans by providing more thorough initial characterizations of water quality problems, thereby reducing the extent of follow-up monitoring needed to complete a TMDL.

Historically, DEM prepared a report, known as the "305(b) State of the State's Waters Report" which summarized its periodic assessment results on a statewide basis. Under EPA's new guidance, DEM will report assessment results in a new report, known as the Integrated Report, which combines the reporting for 305(b) with the 303(d) listing of impaired waters. DEM plans to utilize this format for the first time in 2006.

3.7 Recommended Program Enhancements – Agency Roles & Coordination

- The DEM-OWR needs to build its capacity to conduct ambient water quality monitoring by hiring staff with appropriate expertise, including aquatic biologists, that can be dedicated to the function of monitoring and assessment. A monitoring coordinator should be designated within the DEM-OWR.
- Staff support and operational resources should be provided to the RIEMC in order to support its role as an effective forum for coordinating various monitoring activities in the state, facilitate the transfer of data and information, encourage collaboration and joint-planning where appropriate, and evaluate progress on the implementation of a comprehensive environmental monitoring strategy..
- Via the Coordination Team, as appropriate, a written agreement addressing interstate water quality issues, including monitoring, should be developed and executed between RI and MA as well as RI and CT.
- The role of the URI-WW Program in coordinating volunteer-based monitoring should be state supported to ensure long-term stability.

4.0 Narragansett Bay and Coastal Waters

4.1 Description of the Resource

Rhode Island has identified 156.29 square miles of coastal waters that need to be monitored for water quality assessment purposes. These include estuarine waters, comprised of Narragansett Bay, Mt. Hope Bay and the coastal ponds as well as the near-shore marine waters along the state's southern and Block Island shorelines. Eighty-five percent (85%) of these waters are designated for shellfishing use. (RIDEM, 2002) Rhode Island's coastal waters receive discharges directly from 13 major wastewater treatment facilities (non-industrial), including the state's largest WWTFs operated by NBC. To abate pollution problems in the upper Bay, major upgrades in the wastewater treatment facilities, including combined sewer overflow (CSO) controls, are under construction and being planned. As a result, water quality conditions in the upper Bay are expected to improve and there is a need to measure the effectiveness of the sizable investment being made in water pollution control infrastructure. This strategy addresses primarily estuarine waters and excludes the off-shore waters of Rhode Island Sound and Block Island Sound, except with respect to fisheries management.

4.2 Monitoring Objectives– Narragansett Bay and Coastal Waters

- Assess changes in the ambient water quality of the Upper Narragansett Bay, Greenwich Bay, the Providence and Seekonk Rivers as controls on nutrient and pathogen pollutant loadings are implemented over the next ten years.
- Quantify reductions in pollutant loadings from WWTFs and tributaries to the Bay.
- Assess the presence and concentration of pathogens in all estuarine waters on an on-going basis.
- Collect ambient monitoring data from a network of fixed –site stations to characterize conditions, including the extent and frequency of hypoxia, in Narragansett Bay.
- Complete targeted assessments of embayments, coves and coastal ponds in alignment with the rotating basin schedule for rivers and streams.
- Provide data for tracking trends in water quality and changes in ecosystem functioning over time.
- Provide data for tracking trends in the abundance and distribution of finfish, crustaceans and invertebrates in coastal waters.

4.3 Background on Current Monitoring Programs and Gaps in Data Collection

Given the inherent importance of Rhode Island's coastal waters, both Narragansett Bay and the southern coastal ponds have been the subject of numerous research and monitoring activities over the years – some covering decades of data collection. Long-term state efforts include fisheries surveys and bacteriological monitoring in shellfish growing areas. State activities have been supplemented by research programs, both short and long term, with URI-GSO playing a leading role. During the past decade, the Bay has also been the focus of research by federal agencies including EPA-AED and NOAA-NMFS, both of which have facilities, located in Narragansett adjacent to the GSO campus. A listing of current research projects pertaining to the Bay and other coastal waters that are of interest to state managers is included in Appendix D.

The varied monitoring efforts in coastal waters have generally operated separately with no central coordination. This fact was acknowledged in the Narragansett Bay Comprehensive Conservation Plan, completed in 1992, which

recommended a comprehensive monitoring program be further developed and implemented to support effective management of the Bay. In 1992, a final report regarding a monitoring plan for Narragansett Bay was completed by the URI-GSO for the Narragansett Bay Project (NBP) (Taylor, et al. 1992). It was developed with a tiered design and addressed monitoring of the water column, sediments, pollutant inputs and biological resources of Narragansett Bay. Of the five new or expanded programs recommended, four involved data collection and have been partially implemented with modifications from the original plan. They included: (1) augmenting monitoring of pollutant inputs from major rivers into Bay, (2) monitoring the Providence-Seekonk River region, (3) measuring the trend in the rate of accumulation of toxics in sediments, and (4) surveying the quahog population. The last recommendation concerned data synthesis – a task that has not yet been effectively addressed.

Since the plan was completed, the NBEP and DEM have worked with partners (URI and others) to build capacity to monitor Narragansett Bay. Significant progress was constrained by a lack of funding. This situation was alleviated in 1998 when federal funding became available to Rhode Island from what is known as the Bay Window Program. Prompted by concern about the lack of available data to support assessment of the impacts of the North Cape oil spill, the program was developed jointly between the state and the NOAA. Using federal grant funds from NOAA, the program has been instrumental in 1) deploying continuous monitoring stations in the Bay, 2) securing a new fisheries research vessel; 3) supporting bay-related research including monthly surveys of plankton and water quality parameters.

Efforts to systematically monitor water quality in Narragansett Bay are relatively recent. In 1998, the Bay Window Program enabled URI-GSO to deploy continuous monitoring devices at fixed locations (attached to buoys). The need for continuous measurements of certain water quality parameters became apparent after earlier sampling programs employing grab samples failed to provide sufficient data to fully characterize the nature of water pollution problems in the Providence and Seekonk Rivers and upper bay. Initiated at three locations maintained by URI-GSO, the network grew by two stations deployed by NBC as part of an EMPACT project funded by EPA, as well as two stations deployed by NBNERR on Prudence Island. Continued operation of the stations was made possible via various federal funding sources including the NOAA Bay Window Initiative and EPA (National Coastal Assessment and PPG funding). The network expanded to 10 stations in 2004 with multiple agency participation. The agencies use similar instrumentation to measure salinity, temperature, dissolved oxygen, pH, chlorophyll *a* and in some cases pH and turbidity.

In addition to the fixed-site network, volunteer-based surveys of low dissolved oxygen conditions, conducted for five years (1999-2003), have documented the presence of hypoxia in the upper half of Narragansett Bay. Organized by the NBEP, the program, known as “The Insomniacs Surveys” drew upon the resources of federal, state and local entities in a volunteer effort that was aimed at gaining a better understanding of the extent of hypoxia in Narragansett Bay. The data from these efforts, processed by researchers and students at Brown University on a volunteer basis, has been used in the state water quality assessment process. In 2003, the key participants agreed to end the surveys and seek a more cost-efficient means of monitoring hypoxia. On a more limited basis, The NBEP, working with DEM and Brown, resumed surveys in 2005.

During roughly the same period, two research efforts were initiated that are also providing data on conditions in the Bay. Within the Bay Window Initiative, the NOAA - National Marine Fisheries Service (NMFS) began monthly trawls of the Bay in its deeper channels using a towed, undulating instrument array. Data collected include: time, position, depth, temperature, salinity, chlorophyll, fluorescence, dissolved oxygen, PA, photosynthetic efficiency, and certain zooplankton and phytoplankton measurements. There are plans to add nutrient sampling in 2006. DEM and NOAA are continuing to evaluate how to integrate this dataset into state programs.

EPA's National Coastal Assessment Program, active since 2000, has collected water column, sediment, benthic community, and fish tissue contamination data, from 106 stations in Narragansett Bay and RI coastal waters. While the frequency of sampling was limited, the data should be reviewed and applied to enhance state water programs where feasible. Many of the parameters do not directly correspond to water quality criteria, but the data collected is

expected to be useful in the continued development of indicators and refined monitoring strategies. According to EPA, the NCA datasets constitute a valuable set of benchmarks that can be used to help establish reference conditions. DEM recently agreed to work with EPA and URI-GSO to continue this program during 2005.

Historically, assessment of the designated uses of Rhode Island's marine and estuarine waters have relied largely upon bacteriological data generated by the DEM Shellfish Program and HEALTH bathing beach program. (99% are considered assessed). In recent years, hypoxia surveys have provided a more complete set of data with which to assess water quality conditions especially in support of the aquatic life use. However, there are still gaps in the data with **25% of coastal waters remaining unassessed for aquatic life use**. Additionally, there are other gaps in data concerning the habitat and marine life in the Bay that resource managers need to both improve understanding of the Bay ecosystem as well as support initiatives such as habitat restoration.

4.4 Sampling Design

Management needs pertaining to coastal waters, including Narragansett Bay, influences the selection of monitoring approaches. A review of data needs within programs quickly leads to the recognition that a single sampling design will not fulfill all critical data needs. Accordingly, multiple sampling approaches are necessary to adequately monitor Rhode Island's estuarine and marine waters. The planned approaches constitute variations of fixed-site sampling designs with different locations, parameters and sample frequency being employed to support specific program needs. The expected adoption of a new criteria for dissolved oxygen (DO), which incorporates variable time periods of exposure has emphasized the need for collection of continuous measurements of DO and related parameters. The fixed-station network, from which continuous data are collected, does not provide sufficient geographic coverage of all coastal waters and needs to be complimented by targeted monitoring conducted on a rotating basis. Other programs including the bathing beach, shellfish growing area and certain marine fisheries programs have specific geographic targets that are most effectively addressed via a targeted sampling approach. With respect to tracking the general conditions in Narragansett Bay and other coastal waters, DEM-OWR plans to integrate data from various sources in order to complete its assessment of water quality conditions. DEM has not selected a probabilistic sampling design largely because local management concerns have generally required other approaches in terms of sampling location and frequency.

The key components in the sampling approach for coastal waters include: (1) fixed station network, (2) targeted water quality assessments; (3) bacteriological monitoring (fixed-stations); (4) marine fisheries surveys; (5) benthic habitat; (6) sediments; (7) flow and circulation; and (8) fish tissue contamination.

4.5 Fixed-Site Monitoring Network – Narragansett Bay

The fixed-site network is an essential component of bay monitoring. A total of 13 stations are currently operational. (Figure 4, Table 5). The stations were located strategically to transect the length of Narragansett Bay and serve as sentinels of changing conditions. There is a concentration of sites in the upper Bay purposefully located as a result of wastewater discharges and consideration of Bay hydrodynamics. DEM is planning to review various datasets (Nu-shuttle, NCA, etc.) to evaluate whether the existing buoy locations should be adjusted. Six stations are fixed to docks or piers; six stations are attached to buoys and deployed seasonally (spring to fall). The buoys are normally removed in the winter to prevent ice and storm damage. The network provides continuous data measurements from typically a surface and bottom depth at each location. The parameters measured at each station include: dissolved oxygen, temperature, salinity and chlorophyll. Turbidity is also measured at select sites. The station instruments are maintained with visits generally at least every two weeks. Some stations are equipped with telemetry that allows regular transmission of data, while others require manual downloading as part of the bi-weekly maintenance schedule.

Under the auspices of the Bay Window Program, the various agencies engaged in Bay water quality monitoring convened earlier in 2004 to evaluate and plan for future expansion of the fixed station network. The participating

agencies, which all maintain stations with similar instrumentation, include DEM-OWR, URI-GSO, NBNERR, NBC and RWU. Through a series of meetings that also involved key state water programs, a plan emerged for the long-term expansion of the network. It recommends that 19 stations be eventually deployed in order to provide more comprehensive coverage of the Bay. There are more stations located in the upper Bay where changes in water quality are expected as the result of major improvements to the WWTFs, including the abatement of CSOs. It is appropriate to phase in the expansion of the network and re-evaluate the number and proposed locations of stations over time in light of new data. Technological advances and adapting management needs. Additional detail on implementation is found in Section 9.3.

Given the multiple parties involved in the network, there is a clear need for coordination to ensure both the reliability of the network and the comparability of data generated from different stations. The agencies involved have agreed to work toward a common standard operating procedure (SOP) as well as joint data management. Work is ongoing toward finalizing the SOP and developing an efficient data management system among the multiple agencies. Over time, the network operations should be reviewed to consider enhancements, such as upgrading to satellite-based telemetry, and to capitalize on cost-saving opportunities arising from technological advancements.

During 2004 & 2005, DEM-OWR relied on data from the fixed-station network to systematically track water quality conditions in the upper bay. OWR staff reviewed data daily from a subset of fixed-stations deemed most critical in terms of signaling hypoxia. The data was used in combination with other information available in DEM to provide weekly updates on water quality conditions and determine whether conditions indicated a need for more intensive monitoring (targeted dissolved oxygen surveys). DEM posted the updates and data summary charts on the web. This work was coordinated with the Bay Assessment and Response Team (BART) with the objective of providing information to local communities to support preparations for responding to possible events such as fish kills.

The fixed-station network serves as the primary source of baseline data to characterize important aspects of Bay water quality. It should be maintained for the long-term in order to build datasets that will allow scientists to discern actual trends from the natural variability that occurs in estuarine ecosystems. While reliant in the past on specially designated federal funds, the continued operation and maintenance of the network needs to be assured with a consistent commitment of state funding.

4.6 Dissolved Oxygen Surveys in the Upper Half of the Bay

There is agreement that additional data from summer months is needed to characterize the duration and frequency of hypoxia in the upper half of Narragansett Bay. In 2004, the NBEP, working with partners, was able to conduct rapid assessment surveys in Greenwich Bay at 15 stations in the months of June, July and August with contributions of labor and boat access. In 2005, the Bay Window Program provided one new instrument to speed field data collection but the capacity to survey shallower areas remains constrained. As of September 2005, the NBEP working with Brown & DEM had conducted 4 surveys of the upper Bay. To support periodic larger surveys in the upper half of the Bay, additional equipment needs to be secured. A team approach would be continued with annual targeted surveys planned to supplement the data derived from the fixed-station network and other sources.

When conditions deteriorate, there is a need to conduct targeted monitoring for the purposes of understanding the cause and extent of the event; e.g. hypoxia resulting in a fish kill. Typically, the work must be done quickly and over a short time frame (e.g. a few days). DEM currently has a limited capacity to conduct such work. Over time, additional equipment and cross-training of staff is needed to enhance this capability. If capacity to conduct summer surveys were increased as described above, then the equipment would also be available to respond to this need.

Figure 4.

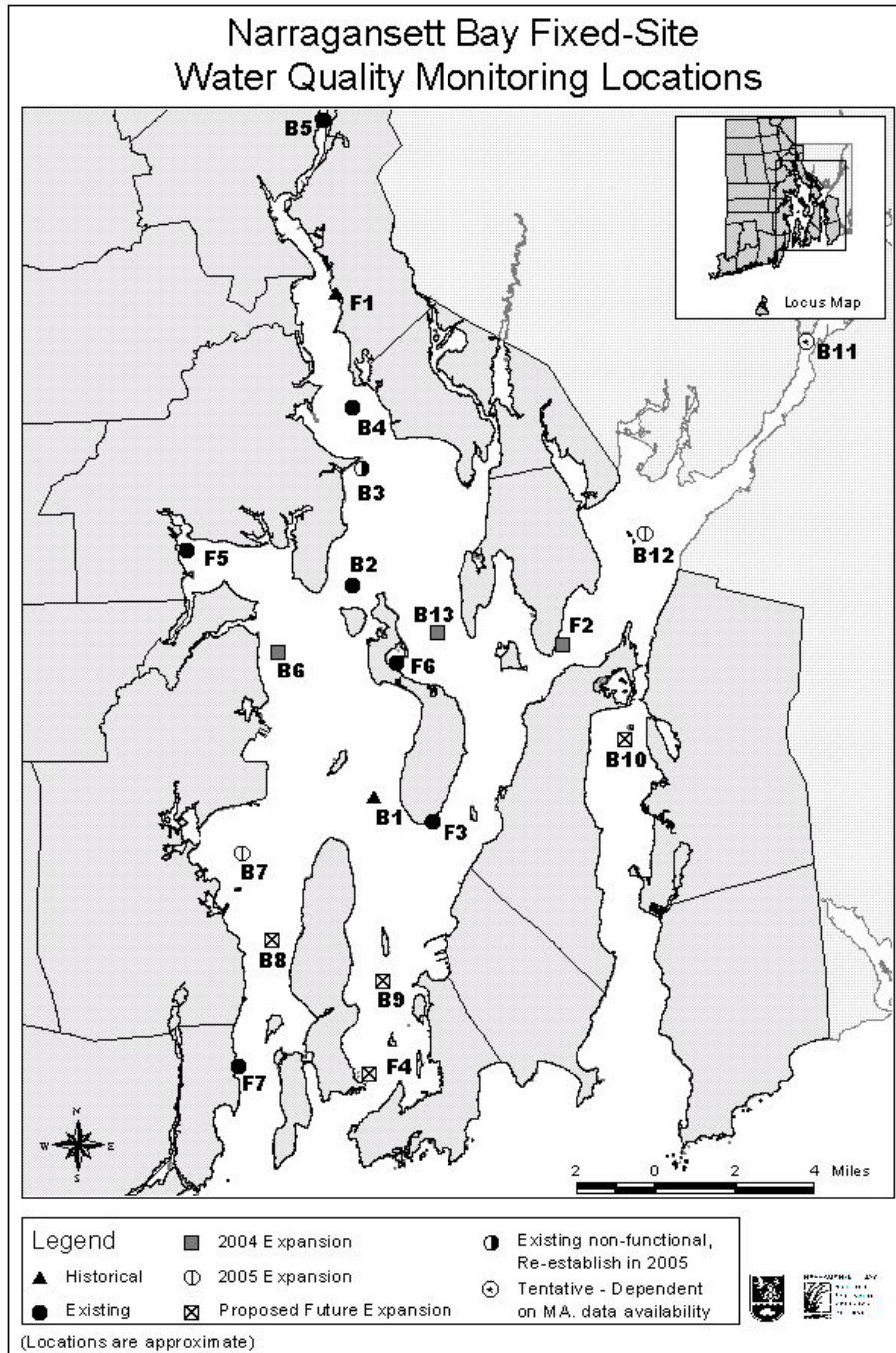


Table 5. Fixed –Site Water Quality Monitoring Network in Narragansett Bay - 2005

Map Label (Refer to Figure 4)	Location	Station Type	Agency Servicing Station	Sampling Locations	Telemetry	Data History	Comment
Stations Operational in 2004(a)							
B5	Phillipsdale/ Seekonk River	Dock	NBC	Surface & Bottom	Yes	October 2001 - present	Seasonal
B4	Bullock's Reach (lower Providence River)	Buoy	NBC	Surface & Bottom	Yes	May 2001-present	Seasonal
B2	N. Prudence	Buoy	GSO (b)	Surface & Bottom	Yes	July 1999-present	Seasonal
B13	Poppasquash	Buoy	NBNERR	Surface & Bottom	Yes	July 2003-present	Seasonal
F5	Greenwich Bay (Greenwich Bay Marina)	Dock	GSO (b)	Surface & Bottom	Yes – bottom only	June 2003 - present	Year-round
B6	Mount View	Buoy	GSO(b)	Surface & Bottom	Yes	New	Seasonal
F6	Potter's Cove	Dock	NBNERR	One level	No	Dec 1995-present	Year-round
F3	T-Wharf	Dock	NBNERR	Surface & Bottom	No	July 2002-present (c)	Year-round
F7	URI GSO Dock	Dock	GSO	One level	No	June 1994 - present	Year-round
Stations Established in 2005							
F2	Roger Williams U.	Dock	RWU	New			
B3	S. Conimicut Point	Buoy	GSO (b)	Historical; replaced w/ new station in 2005	Yes	June 2005 - present	Seasonal
B7	Quonset Point	Buoy	NBNERR	New	No	July 2005 - present	Seasonal
B12	Mt. Hope Bay	Buoy	NBNERR	New	Yes	June 2005 - present	Seasonal
Future Expansion Needs							
F1	Pomham Rocks	Dock	TBD	Historical/ Future upgrade	Under Evaluation		
B10	Sakonnet River	Buoy	TBD	New			
B11	Upper Mt. Hope Bay (Massachusetts)	Buoy	TBD	New			
F4	Fort Wetherill	Dock	DEM – F&W	New			
B8	Lower West Passage	Buoy	TBD	New			
B9	Lower East Passage	Buoy	TBD	New			

- a) Certain stations may have been maintained by different agencies in prior years.
b) URI-GSO will maintain the stations under contract to DEM-OWR.
c) Data is available from September 1996 – July 2002 from a nearby location.

NOTE: In late 2004, the NBC station at Bullock's Reach was destroyed. New equipment was loaned by DEM to NBC to ensure the location was deployed in 2005. NBC plans to deploy new equipment at the location in 2006.

4.7 Rotating Assessments of other Estuarine/Coastal Waters

The fixed-station network provides a vital dataset for Narragansett Bay, but there are limitations in extrapolating the data to its smaller coves and embayments. In addition, the network does not cover the state's coastal ponds. There is a need to collect additional data to identify other locations within the Bay and coastal waters that may suffer from poor water quality. To screen for such problems, DEM will develop a rotating assessment program that would provide for periodic assessments of targeted portions of the Bay and coastal ponds. The focus would be physical and chemical water quality parameters; e.g. dissolved oxygen, nutrients and pathogens. This would involve segmenting the Bay and other coastal waters into assessment units. Instrumentation similar to the fixed-station network would be deployed on a temporary basis; e.g. one sampling season. A schedule for this work would be devised in conjunction with the scheduling of the rotating basin assessments for rivers and streams. The goal would be to integrate the two activities as much as feasible; e.g. conduct the coastal assessment study during the same time period that the tributary streams are being assessed. There are at least 7 coastal ponds and at least a dozen cove and embayment areas that should need to be monitored over the next 5-10 years.

4.8 Bacteriological Sampling

Among the state's coastal waters, all waters classified as SA and SA{b} are designated for shellfishing uses. This consists of 84,902 acres or about 85% of the total; which excludes Rhode Island Sound and Block Island Sound. Within designated shellfishing waters, 79%, or 66,733 acres, are currently open with 21%, or 17,344 acres, closed permanently or managed conditionally. The DEM Shellfish Growing Area Monitoring Program provides an extensive dataset concerning pathogens in the Bay. The program, which assures compliance with the USFDA National Shellfish Sanitation Program (NSSP), collects samples from 17 shellfish growing areas and analyzes for total and fecal coliform bacteria. The growing areas encompass all of Narragansett Bay and its shellfish harboring tributaries, all of the south shore coastal salt ponds, Little Narragansett Bay and Block Island. There are 303 fixed stations established in the program with from 9 to 39 stations sampled in each growing area. The frequency of sampling varies with the management status of the growing area. All open or conditional areas are sampled at least six times per year. With the exception of areas monitored by NBC, permanently closed areas are not regularly sampled, which creates a gap in the data coverage. There are currently 32 permanently closed areas. A map of closed areas is included in Appendix E; detailed descriptions of the areas are available at www.state.ri.us/dem/maps/mapfile/shellnar.jpg. Pathogen data, and other data where relevant, supports assessment of the shellfishing use and decisions to open and close areas to shellfish harvesting. Monitoring within the Shellfish Program should be expanded to periodically survey closed areas as actions to control sources of pathogens are implemented via CSO abatement, WWTF improvements and water quality restoration plans (TMDLs). The schedule would involve a rotating approach and should be aligned with other monitoring activities where feasible.

A second source of data on pathogens is the HEALTH Bathing Beach Program that ensures all coastal bathing beaches are sampled for enterococci. DEM will be incorporating numerical criteria for enterococci in the state's water quality regulations in the next rule revision (pending). HEALTH currently licenses 70 coastal beaches. Among these, 20 are located in waters considered estuarine; while the remainders are adjacent to marine waters, notably Rhode Island and Block Island Sounds. With federal support via EPA EMPACT and BEACH Act grants, over the last five years HEALTH was able to develop and expand their program for coastal beaches to increase sampling frequency as well as investigation of pollution sources causing beach closures. HEALTH also improved public notification procedures and developed a web-site www.health.state.ri.us/environment/beaches. A risk-based approach is used to determine sampling frequency which ranges from twice per season to weekly. HEALTH is planning on expanding sampling to include near-shore and off-shore areas at selected beaches in order to discern of pathogens from CSOs from that of local sources.

Other sources of pathogen data are NBC and the several volunteer monitoring programs including the Pondwatchers Program of the Saltpond Coalition, which is believed the oldest operating volunteer monitoring group in the state, as well as the Blue Water Task Force of the RI Surfriders Foundation which samples beaches. Due to the extensive CSO abatement project underway, the NBC conducts monitoring for pathogens in the estuarine Providence and Seekonk Rivers as well as other freshwater tributaries to the upper Bay including the Moshassuck, Blackstone, Woonasquatucket and West Rivers. Sampling for fecal coliforms has been conducted weekly for several years and is on-going. DEM relies on this data, along with the extensive shellfishing data and in some cases volunteer data, to assess whether estuarine and coastal waters support their designated recreational uses. The water quality standard for primary contact recreational use (swimming) is expected to change with the addition of enterococci criteria as the indicator. Sampling strategies will need to be modified in the future following promulgation of the change in criteria.

4.9 Marine Fisheries Surveys

The marine fisheries surveys being collected generally provide DEM with fairly comprehensive data to support current program decision-making. The data being collected follows species of importance through their life cycle: ichthyoplankton, juvenile and adult stages. The Marine Fisheries Section intends to continue all existing surveys on a long-term basis. In addition to work by DEM-F&W, URI-GSO has had a long-term commitment to conducting finfish trawl surveys that has sampled two locations for a longer period of record, since 1959, than the DEM-F&W data which initiated in 1979. DEM considers the URI data very valuable and uses it to corroborate interpretation of its own data and to infer long-term trends. Use of the URI-GSO data in conjunction with DEM data enhances confidence in the fisheries program analysis and decision-making.

The population dynamics of finfish are complex and DEM-F&W is involved in efforts to collect additional information about the stressors on particular fish stocks. The expanded baseline water quality information collected in coastal waters should over time be of benefit in discerning and understanding long-term trends in fisheries data, including peculiar changes in species abundance that cannot be attributed to fishing activity. More evaluation is needed to determine how best to improve the sharing of data and other information among programs to facilitate data integration and synthesis. Over time, there may be opportunities to incorporate collection of additional water quality parameters into fishery surveys as part of the on-going integration process. There is a gap in water quality data in the marine waters of Rhode Island Sound with respect to analyzing management issues with species that populate and migrate through these waters. The RV Chafee provides the Marine Fisheries Section with enhanced capability to conduct surveys in this area and DEM expects an expansion in the range of the surveys will occur in the coming years.

DEM F&W also has a long record of surveying the population and distribution of shellfish resources in coastal waters. An annual dredge survey has been conducted since 1993. Baseline work allowed all major shellfish areas to be surveyed (over 400 stations). Subsequently, about 25% of the stations, selected randomly, are re-sampled annually. The annual survey is supplemented by site or area specific surveys conducted on an as-needed basis using dredge or manual (via scuba diving) methods for sample collection. There are some areas of Narragansett Bay that are too shallow to access with a dredge boat or are inaccessible for other reasons; e.g. mooring fields, etc.) With a couple, exceptions, the coastal ponds have been surveyed, although not regularly. The exceptions are Quicksand Pond, which is private, and Trustom and Card's Pond which are within USF&W jurisdiction..

DEM-F&W also conducts a shellfish disease survey that twice per year examines shellfish, both wild and cultured, for disease or abnormalities. Samples are collected from twelve locations.

With respect to crustaceans, long-term data are available on lobsters, but not crabs. Long-term trends for crabs can be assessed using the URI-GSO survey and data from DEM-F&W trawls in recent years. In addition, the DEM-F&W has been discussing with the lobster industry a potential enhancement to the existing surveys to address limitations that result from the current trawl collection technique that doesn't cover the complete range of bottom habitats that lobster inhabit. Institution of an un-vented pot survey is the approach under discussion.

DEM F&W also conducts a horseshoe crab survey. This effort involves about 75 volunteers who either walk the beaches, kayak or wade on evenings of the new and full moons in May and June which is the mating season. Animals are counted as single males or females or mating pairs.

4.10 Phytoplankton

Harmful phytoplankton monitoring was added to the DEM Shellfish monitoring program in 2000. The introduction of this work serves a public health objective. The data provides a basis for targeting where shellfish meats should be collected for bioassay which determines the need for the closure of shellfish grounds due to the presence of Paralytic Shellfish Poisoning (PSP) and Amnesic Shellfish Poisoning (ASP). During its regular monitoring runs for pathogens, DEM-OWR collects two phytoplankton samples in the Bay or coastal ponds. The samples are analyzed and identified in the HEALTH laboratory as a means of screening for the presence of biotoxins. The identification is made using a microscope, identification keys and photographs provided by the FDA. When phytoplankton samples indicate the presence of certain species of concern, the information triggers collection of shellfish samples by DEM-F&W for analysis of their meats using mouse bioassay for red tide conditions, or high pressure liquid chromatography for amnesic shellfish poisoning.

Rhode Island has never experienced an outbreak of harmful phytoplankton at levels sufficiently toxic to cause a shellfish closure. However, the need for vigilance was reinforced in 2005 when a large red tide event occurred in coastal waters ranging from Nova Scotia to Massachusetts. This event prompted an expansion of DEM sampling efforts in off-shore waters and identified a need for DEM to have ready access to scientific experts that can perform taxonomic identification of phytoplankton species.

4.11 Benthic Monitoring

Sessile fauna of the benthos can be easily re-sampled, and respond to conditions in the overlying water and deposited sediments. (Ovaatt in RIEMC 2005). They represent excellent biomarkers for monitoring anthropogenic and climate change over time. URI-GSO has been conducting benthic monitoring in Narragansett Bay since 1999 at selected locations in Narragansett Bay, both as part of its own activities and in collaboration with the EPA National Coastal Assessment program. Work will continue in June 2006 with the collection of cores from four locations. A long-term benthic monitoring program should be developed as a future update to this strategy.

4.12 Submerged Aquatic Vegetation & Coastal Wetlands

The NBEP, with partners, conducted a 1996 baseline survey of coastal habitats that identified 100 acres eelgrass beds, also known as submerged aquatic vegetation (SAVs), and 2,323 acres of salt marsh in and along Narragansett Bay. The remainder of the state (South Shore, Little Compton and Block Island) was mapped in 1999 and identified another 570 acres of eelgrass. Both surveys used aerial photography and photo-interpretation to ultimately produce maps that were published in atlases of coastal habitat. A new aerial overflight is scheduled for the summer of 2006 and will support an analysis of the loss and gains in habitat types; e.g. eelgrass beds for the intervening ten year period. The flight is funded by RI Coastal and Estuary Habitat Restoration Trust Fund but there is a continuing need to secure funds for photo-interpretation. A long-term strategy for monitoring SAVs and coastal habitats should be developed and reflected in this strategy. To date, there has been consensus that such mapping should occur at least every five years.

4.13 Macroalgae Surveys

DEM, via OSPAR, funded a pilot project conducted by the NBEP and URI during the summer of 2005 as a step toward developing a longer-term strategy for monitoring the extent of macroalgae in the Bay. The overall objective is to measure the distribution of nuisance macroalgae (*Ulva*, etc.) and improve the understanding of the response of

these algae to nutrient loads. Testing of field methods was started in 2005. Further work is needed to determine the most cost-effective means of collecting data on the location and abundance of macroalgae in order to refine a long-term monitoring strategy for macroalgae and update this strategy accordingly.

4.14 Circulation & Tides

The primary source of data on the hydrodynamics of Rhode Island's coastal waters is NOAA. NOAA, through the National Ocean Service (NOS), collects and provides real-time access to physical and oceanographic data. Within NOS, the Center for Operational Oceanographic Products and Services (CO-OPS) oversees the National Water Level Observation Network that provides data from tidal stations. Historical data are currently available for 16 stations located throughout Narragansett Bay and another four located along the southern RI coast and on Block Island. CO-OPS also administers the Physical Oceanographic Real-Time System (PORTS) which provides real-time water level, current and other oceanographic and meteorological data from certain bays or harbors. There are five PORTS stations in Rhode Island (Providence, Conanicut Point, Prudence Island, Quonset Point and Newport) and another located in Fall River, MA. DEM contracts with NOAA to sustain the operation of PORTS. While PORTS was developed as a service to support safe and cost-effective navigation, the data is used by DEM and others in applications regarding water quality; e.g. modeling efforts. For example, NBC has contracted with URI-GSO to develop a ROMS model of circulation for the upper bay.

4.15 Fish Tissue Contamination

As there is no established program for assessing fish tissue contamination at the state level, DEM and HEALTH rely on data collected by other entities. In the case of coastal waters, the primary source of data on fish tissue contamination is the EMAP National Coastal Assessment program. The data need to be reviewed by the state in the next water quality assessment process, which will be initiated in 2005, to determine if any additional monitoring will be needed in the 2005-2010 period of this strategy.

4.16 Bioinvasives

A long-term monitoring strategy for tracking bioinvasives in coastal waters will be incorporated as a future revision to this strategy.

4.17 Sediments

A long-term strategy for monitoring sediments in coastal waters will be incorporated as a future revision to this strategy.

4.18 Recommended Program Enhancements – Narragansett Bay & Coastal Waters

- The fixed-station network in Narragansett Bay must be funded to sustain continuous data collection for the foreseeable future with the DEM-OWR providing coordination among the participating partners that include NBNERR, NBC, URI-GSO and RWU. – *in progress; additional resources required for FY2007*
- Rapid dissolved oxygen surveys of the upper half of Narragansett Bay should be continued to improve understanding of the spatial extent of hypoxia. Data should be synthesized to refine survey targets and periodically assess need for continued data collection.- *in progress; additional resources required*
- DEM should acquire additional equipment and training to enhance its capability to rapidly respond to events such as fish kills, large spills etc. in coastal waters.

- Portions of the Bay and the coastal ponds should be periodically monitored and assessed on a rotating schedule that is aligned, where feasible, with the work planned for inland watersheds.
- The DEM shellfish monitoring program activities should be expanded to provide for periodic sampling in closed growing areas to measure the effectiveness of planned pollution abatement actions.
- The large tributary rivers to Narragansett Bay should be regularly monitored near their mouths in order to estimate pollutant loadings. See Section 5.0 on Rivers and Streams.
- Marine fisheries surveys should be extended to fill gaps in areas off-shore of interest to fishery management programs. – *in progress*
- Fish tissue contamination data available from the EPA NCA for the Bay should be reviewed as part of developing a long-term strategy for monitoring for such contaminants.
- The program to periodically map the extent of submerged aquatic vegetation (eelgrass) in coastal waters should be refined and implemented. – *in progress, additional funding required*
- A strategy for monitoring the extent of macroalgae should be developed.
- A program to map benthic habitats should be developed.
- A long-term strategy for surveying bioinvasives in Narragansett Bay should be refined and implemented.

5.0 Freshwater Rivers and Streams

5.1 Description of the Resource

Rhode Island has 1,498 miles of rivers and streams mapped at a 1:24,000 scale which range from numerous small first order headwater streams to the large, well known main stem rivers. The rivers are used for aquatic life habitat, fish consumption and recreational activities. A subset of rivers are tributaries to drinking water supply reservoirs. In the northwest corner of the state, marked by rolling hills and higher elevations, the rivers have higher gradients and flow slightly faster than the streams in the coastal lowlands which cover more than half the mainland and the Rhode Island's islands. Except for small portions of state bordering Connecticut, all of northern Rhode Island is drained by river systems that discharge into Narragansett Bay, while rivers in the southern Rhode Island drain directly into Rhode Island Sound. Freshwater rivers in RI are the receiving waters for six major WWTF discharges (non-industrial).

(Note: While named as rivers, the Providence, Seekonk and Sakonnet Rivers are estuarine waters.)

5.2 Monitoring Objectives– Rivers and Stream

- Assess the ambient water quality conditions in all rivers and streams over a five- year period. 100% of river and stream miles will be assessed for aquatic life and recreational uses by 2011.
- Monitor water quality in the state's three largest rivers (Blackstone, Pawtuxet and Pawcatuck) on a regular basis for nutrients and other selected parameters to allow for estimates of pollutant loadings into coastal waters. Ensure that comparable data is collected from the Taunton River in Massachusetts.
- Assess fish tissue contamination in all rivers and streams supporting fish of edible size by 2014.
- Expand the network of stream flow gages from 19 to 29 by the addition of ten high priority locations.
- Provide data to support measurement of water quality trends over longer periods of time.
- Provide data to track trends in abundance and distribution of freshwater and anadromous fish.

5.3 Background on Current Monitoring Programs and Gaps in Data Collection

With respect to the freshwater rivers and streams, the 2004 305(b) report indicates significant gaps in available data. Over the last ten or more years, the existing baseline monitoring programs have utilized a fixed station approach to the monitoring of river and streams, wherein samples are collected over time from the same location. This approach, the most common practice among states (ASWPCA, 2003), has been used by DEM and its partners/contractors including URI and USGS for physical/chemical parameters, and RWU and ESS Group for biological monitoring. The chief disadvantage of this approach is that it led to a sizable gap in the geographic coverage across the state.

Overall, sixty-two percent (62%) of the river miles in the state were not assessed due to a lack of available data on water quality conditions. In 2002, RWU chose not to continue its macroinvertebrate monitoring program which had provided data from 1992 on 42 stations in RI rivers and streams as well as three in stream segments located in bordering Massachusetts. Subsequently, DEM contracted with ESS Group to sustain monitoring at 45 stations statewide. DEM began choosing new sampling locations in an effort to reduce the existing data gaps. In 2002, the Blackstone and Pawcatuck River watersheds were targeted with 20 new streams being sampled. Six (6) additional streams were added in other watersheds in 2003.

Current programs for rivers have involved both physical and chemical parameters as well as biological assessments. For decades, the USGS survey has collected water quality and flow data from the state's largest rivers: the Blackstone, Pawtuxet and Pawcatuck as well as the Taunton River in Massachusetts that empties into Mt. Hope Bay. The parameters measured included nutrients, pathogens, BOD, COD, and trace metals among others. The quarterly sampling data has been relied upon by the state to estimate the nutrient loadings from rivers that discharge into coastal waters – most importantly the Upper Bay and little Narragansett Bay (off Westerly). The water quality component of this work was suspended in 2002 when DEM was unable to provide state matching funds to support the continuation of an agreement with USGS. This creates a critical data gap from the perspective of tracking the pollutant loadings, including nutrients, into coastal waters and disrupts data that could support long-term trend analysis.

In 1991, to supplement the monitoring by USGS, DEM-OWR first entered into agreements with the URI Civil and Environmental Engineering Department (CEE) to conduct baseline monitoring at 25 stations across the state. These stations were a subset of those being sampled for biological assessment. A table in Appendix F lists the stations and years for which data are available. Physical and chemical data were collected quarterly.

Biological monitoring programs support assessments of the biological condition of a waterbody using biological surveys and other direct measures of resident biota in surface waters. The survival of a species or aquatic community is dependent upon favorable instream environmental conditions. The effects of pollutants are evidenced in the population of organisms, species composition and diversity, and the physiological condition of the natural aquatic communities. Two types of biological monitoring programs have been used to evaluate water quality. Multiple plate artificial substrates have been used in deep rivers for the period 1974-2002. This long-term data collection was suspended following the retirement of the aquatic biologist who conducted this work in the DEM-OWR. EPA's Rapid Bioassessment Protocol (RBP) has been in use since 1991 on shallow (wadeable) streams and rivers. In addition, DEM-F&W has conducted fish population surveys across the state using a consistent protocol that involves electrofishing. Between 1993 and 2002, 83 lakes and 277 rivers and stream locations were surveyed and the data is in the process of being prepared for publication. DEM is exploring how this data might be applied to the water quality assessment process through the development of a fish index of biological integrity (IBI).

There are other significant gaps in the available data concerning rivers and streams. DEM lacked bacteriological data needed to assess recreational use on 70% of the river miles. Additional data (periphyton) is needed from rivers in order to develop nutrient criteria in the water quality standards program. Fish tissue data (toxics), which are used to determine suitability for fish consumption, are available on less than 1% of the river miles in the state. This reflects the fact that Rhode Island has no established program for evaluating fish tissue contamination. Available data has been largely generated by EPA-AED research in the state and special studies; e.g. TMDLs.

Finally, with respect to measuring flow, the existing network of 19 continuous gages in the state limits the ability to accurately estimate or confirm flow conditions in many rivers and streams. The WRB-DEM Streamflow Committee has recommended that the network of gages be increased to 54. (DEM-WRB-USGS Streamflow Committee, April 2004) See Appendix I for list of current and recommended gaging stations.

5.4 Selection of Sampling Designs

In recognition of the large gaps in river and stream data, DEM, with the assistance of its consultant, reviewed various options for sampling designs for rivers and streams. Five general sampling design options were considered: Fixed station design; "Synoptic" design; Intensive survey; Geometric design; or Probabilistic design. The attributes, advantages, and disadvantages of each design were recently described in a separate report (MBI 2003).

The choice of which spatial design(s) to employ in a multifaceted and comprehensive monitoring and assessment program should include considerations of all activities and programmatic objectives that must be satisfied by the same datasets. Given the reality that Rhode Island has multiple and equally important water quality management

objectives and programs to support, some of which may benefit from monitoring outputs and outcomes, consideration of more than one spatial design seemed appropriate. The goal should be to select a sampling design or set of designs that supports *all* state water quality management needs with the same datasets and in the most cost-effective manner. (See Appendix F). An equally important consideration is ensuring that monitoring and assessment is conducted at the same scale at which water quality management takes place. For this consideration, an intensive sampling design such as the geometric design is more appropriate than the probabilistic design. While the EPA has been encouraging the use of probabilistic designs and they appear to offer some advantages for assessing larger regional areas, this approach was not deemed most suitable for Rhode Island. Water quality management programs need more robust datasets than those generated by the probabilistic approach that relies on the extrapolation of results from a relatively small number of sampling sites. For example, while a probabilistic design applied to Wadeable streams may estimate the percentage of river miles that are impaired on a statewide basis, it does not identify where all those streams are located. DEM also found the approach to be labor intensive in terms of establishing access to sampling locations.

Based on the feedback received following a workshop held in July 2003 on the monitoring design options document (MBI 2003), DEM has modified its sampling approach to monitor water quality in rivers and streams. The new approach includes: (1) periodic assessment of rivers and streams applied in a rotating basin approach using an intensive sampling design (geometric design); and (2) regular monitoring at fixed-stations on a limited number of large rivers. The rotating basin approach will involve the periodic monitoring and assessment of multiple sites located in multiple streams and rivers within specific basins or watersheds. This is the approach favored and being applied in some form by most of the States (ASIWPCA 2003). It constitutes a change from past practice in Rhode Island, but is expected to yield significant benefits in terms of more comprehensively characterizing water quality conditions on a statewide basis.

In terms of spatial scale and design, the proposed sampling design would involve an intensive data collection effort conducted at the 10-12 digit HUC watershed scale. Such a design initially focuses on the basic layout and character of individual watersheds being preoccupied with neither point nor nonpoint sources. Thus, it should result in a database that includes an essentially unbiased assessment of all potential influences that are amenable to detection by the chemical, physical, and biological indicators that are used. The primary goal is to directly assess the aquatic resources establishing their condition with respect to *all* of the stressors that are present and being conducted in such a way as to allow causal associations to be demonstrated or at least become apparent. At the same time, it can be customized through the addition of targeted sampling stations to address program specific concerns. Matching the scale of assessment to the scale of management application is critical to the success of making linkages between management actions and monitoring and assessment outcomes. In addition to developing information at the watershed scale, the long-term operation of this approach will yield a dynamic database that supports the ongoing development of the assessment tools and criteria that are vital to an accurate delineation of attainable condition and documentation of the stress-exposure-response relationships that exist within each.

Once the implementation of these management actions has taken place, presumably over a time span of several years, follow-up monitoring conducted within the sequence of the rotating basin approach would provide direct evidence of the effectiveness of the management actions, provided the processes described in the options document (MBI 2003) for sequentially evaluating the data and information are followed. This process presupposes neither success nor failure, but is an objective way to apply multiple indicators to a potentially changing set of conditions. It also has the advantage of simultaneously providing support to all water quality and natural resource management programs within the watershed or river segment. Furthermore, in addition to providing site, reach, and watershed-specific information that is of value to a specific management programs, the accumulation of such data and information across broader spatial scales (i.e., regionally or statewide) will support the development and maintenance of better assessment tools and provide an ongoing assessment of the efficacy of relevant criteria, policies, rules, and legislation.

5.5 Sampling Design for Rivers and Streams – Rotating Basin Approach

The watershed assessment process described here should achieve the systematic and comprehensive assessment of streams and rivers primarily at the 10 digit HUC¹ watershed scale. An ideal size for watershed assessment units are individual subbasins draining 200-300 square miles or major mainstem river segments draining more than 300 square miles and including reaches of 30-50 miles or more. As a preliminary planning exercise, DEM-OWR has grouped sub-basins, based on HUC designations, to create 7 watershed assessment units ranging in size from 172 to 270 square miles. The assessment units represent groupings of sub-basins that contain a total number of river miles in the desired range that will be able to be sampled by the monitoring team. In some cases, the need to apportion workload results in the sub-basins grouped together not being contiguous. Figure 5 and Table 6 show the preliminary organization of sub-basins into watershed assessment units. Appendix H provides additional detail.

Integration of monitoring with major water quality management programs includes consideration of the timing of these program outputs; e.g. TMDL schedule, permitting schedule, basin studies, etc. The final rotating basin schedule will be aligned, as much as feasible, so that monitoring and assessment information is available in a timely manner in order to be of use to these programs. This assures that monitoring and assessment information is available to support the development of actions taken by the management programs and then later to evaluate whether the programs had the intended effect. As part of implementing the rotating approach, DEM will convene a work group to develop a specific five- year assessment schedule and will review the configuration of the assessment units. This will allow various watershed and basin configurations in use by different agencies to be considered with a goal of aligning as much work as feasible to a common configuration. This will foster a unified, more comprehensive approach to the spectrum of water issues in a watershed or basin that is expected to enhance resource protection and management.

Table 6. Watershed Assessment Units in the Rotating Basin Approach

Watershed Assessment Unit		Area (Sq. Miles)	River Miles
1	Blackstone River	232	209
2	Pawtuxet River	232	342
3	Border Areas ²	270	148
4	Narragansett Bay	225	213
5	Urban Rivers ³	229	144
6	Pawcatuck River	197	225
7	Wood River & SW Coastal Ponds	172	165

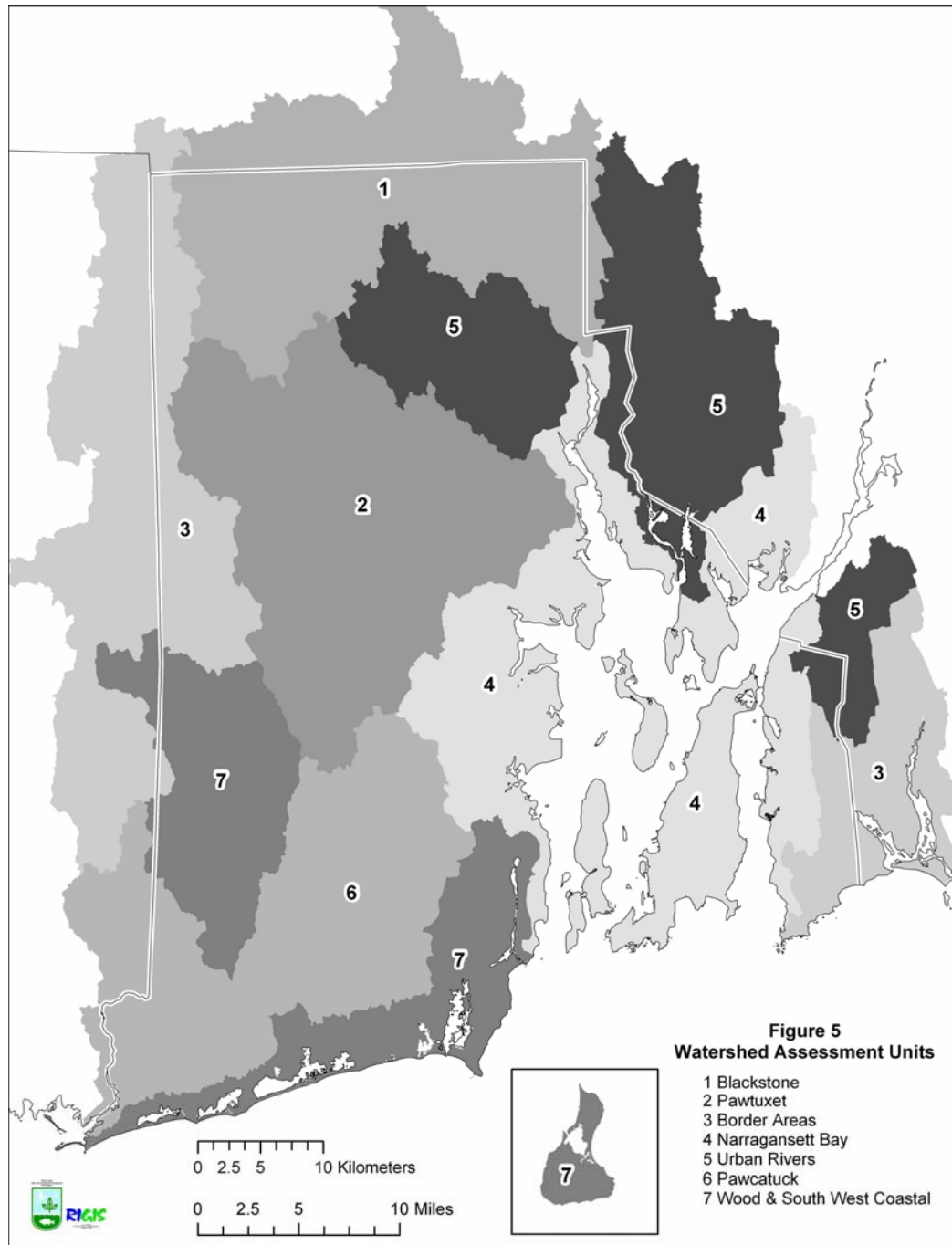
In the geometric design, sampling locations are located proportional to the network of streams within the watershed. In the application of a geometric design, a sampling location is established at the mouth of the targeted river watershed. The upstream drainage area is then halved and stations are located at all stream points with drainage areas of this size. The process continues with the area halved again and stations again located to reflect drainage areas of the corresponding size. The process is typically completed when the drainage area reaches a 1-2 square mile area.

¹HUC – hydrologic unit code; Hydrologic unit boundaries define the areal extent of surface water drainage to a point. USGS developed a hierarchical coding system for HUCs which was subsequently expanded by NRCS. When referring to HUCs, the smaller the number (digit), the larger the drainage area in the HUC. RIDEM is currently working with NRCS and USGS to finalize watershed delineations at the 12 digit scale

² Consists of the RI portions of the Cape Cod and Quinepaug 8 digit HUCs

³ Consists of the Ten Mile, Woonasquatucket, Moshassuck, Palmer and Lower Taunton 10 digit HUCs.

Figure 5. Watershed Assessment Units Proposed to Support the Rotating Basin Approach



During 2004-2005, DEM, working with contractors, will complete a demonstration project in the Wood River watershed that applies this sampling design within certain limitations. It will result in the collection of data from 37 stations in a 90 square mile sub-basin. The data is expected to allow 100% of the rivers and stream miles in the watershed to be assessed for aquatic life and recreational uses. In addition, the data will provide a strong basis on which to design additional targeted monitoring required by the TMDL program that is evaluating low dissolved oxygen in the Pawcatuck River, to which the Wood River is a major tributary. The demonstration project is slated for completion in 2005 and DEM will use this experience to refine the rotating basin approach and sampling design as needed. In 2005, DEM is further applying the approach in a majority of the Pawcatuck River Watershed. Approximately 45 stations are part of the initial sampling design covering approximately 121 square miles of watershed.

The sequence of events within the DEM Five-Year Basin Approach for a given year from the initial screening of assessment issues through the production of a final assessment is described in Table 7. This describes the major milestones and activities including the selection of specific watersheds and river segments for monitoring, planning the monitoring activities, conducting the monitoring, data custody, data management, QA/QC, transformation of data into information, assessment and interpretation of the results, and the making and reporting of conclusions and recommendations. The process requires a central point of coordination within RIDEM and includes direct participation from all RIDEM surface water programs, and either direct or indirect participation by other State and federal agencies and non-governmental organizations as appropriate. A monitoring coordinator is needed to manage the work along with sufficient staffing and resources, either via new positions or contracting, to carry out the sampling field work, analysis, data management and synthesis. Further discussion on implementation is in Section 9.0.

DEM plans to use a team approach to each basin study, where the lead monitoring personnel interact with water resource management program personnel in developing a detailed plan of study for each watershed or river segment assessment. A study team is organized and assigned to each watershed or river segment area and includes a team coordinator⁴, lead members of the sampling team who are responsible for collecting and analyzing the chemical/physical and biological data, and lead representatives from the affected management programs. This is expected to include the RIPDES permitting, TMDL, and WQS programs, but may also include compliance/enforcement, nonpoint source planning and management, and other relevant water quality and resource management issues. A detailed study plan, which delineates the study area boundaries, the scope and objectives, specific personnel assignments, specific sampling locations, specific indicators and methods, parameters, frequencies, and index sampling periods is prepared for each study area. This plan either serves as or is accompanied by preparation of a quality assurance project plan (QAPP) which may be required to be submitted to EPA for review and approval. The plans will be expected to include the water chemistry parameters listed in Table 8 as well as biological monitoring via the RBP protocol and measurements of streamflow. Following internal review and approval, this then serves as the blueprint for the sampling and data collection phase. Lead personnel responsible for a specific indicator are each responsible for assuring data quality, integrity, and adherence to chain-of-custody procedures. Data collected via this process is validated in accordance with the QAPP. All data is validated by lead personnel and verified. Data from each basin study will be managed in accordance with the procedures described in Section 7.0

⁴ The team coordinator should participate in the entire survey and not only coordinate the planning and execution of the sampling, but the development of the data and information and its synthesis into a report and other allied products; this can be a stand alone position or one of the team members assigned to one of the major indicator groups.

Table 7. Important Timelines and Milestones in the Planning and Execution of Rotating Basin Studies

Milestone	Timeline
December - February: (Months 1-3)	Initial screening of the major hydrologic areas takes place by soliciting input from the various program offices and other stakeholders.
February - March: (Months 3 thru 4)	Final prioritization of issues and definition of specific study areas. Resource allocation takes place and study team assignments are made.
March - May: (Months 4 thru 6)	Study planning takes place and consists of detailed map reconnaissance, review of historical monitoring efforts, and initial sampling site selection by the study team. Final study plans are reviewed and approved.
May - June: (Months 6 thru 7)	Final study plans are used to develop logistics for each field crew. Preparations are made for full-scale field sampling.
June - October: (Months 7 thru 11)	Field sampling takes place with field crews operating somewhat independently on a day-to-day basis, but coordinated by the study plan and the team leader. Study team communication takes place as necessary, especially to resolve unexpected situations. Follow-up monitoring may extend the study period into the following spring.
October - February: (Months 11 thru 15)	Laboratory sample analysis takes place for chemical and biological parameters. Raw data is entered into databases for reduction and analysis. The study team meets to review the information base generated by the field sampling and to coordinate the data analysis and reporting effort.
November - May: (Months 12 thru 18)	Information about environmental indicators retrieved, compiled, and used to produce analyses which will support the evaluation of status and trends and causal associations within the study area. Integration of the information (<i>i.e.</i> , assessment) is initiated. Additionally, follow-up sampling may be executed.
May - December: (Months 18 thru 24)	The assessment process is completed by producing working copies of the assessment for review by the study team and a final report.

Table 8. Baseline Parameters Measured in Rivers and Streams during Rotating Assessments

Water Parameter	Measurement Range
BOD (Biological Oxygen Demand)	ppm
Chloride	ppm
Conductivity	1-1000 μ mhos/cm
Sodium	ppm
Hardness (Ca, Mg as CaCO ₃)	ppm
Dissolved oxygen	1-20 ppm
Fecal coliform bacteria	CFU/100 ml
Enterococcus	Enterococci/100 ml
NH ₃ -N (Ammonia)	ppm
NO ₃ -N	ppm
pH	2-10
PO ₄ -P	ppm
Temperature	1-30° C
Total Nitrogen (TN)	ppm
Total Phosphorous (TP)	ppm
Total Suspended Solids (TSS)	ppm
Total Volatile Solids (VSS)	ppm
Dissolved cadmium	ppb
Dissolved lead	ppb
Dissolved copper	ppb
Total iron (Fe)	ppb
Turbidity	0-1000 NTU

ppm =parts per million, ppb= parts per billion

Over time, the biological monitoring component of this approach will be strengthened by the collection of two assemblages of organisms. DEM will initially use the RBP methodology for collecting macroinvertebrate samples. To add a second biological assemblage, DEM plans to incorporate fish surveys once the mechanism to support applying this data in water quality assessment process, the fish IBI, is developed.

While the rotating basin approach is primarily geared to rivers and their associated watersheds, DEM plans over time to align work related to all waterbody types within a watershed unit. For example, this could include initiating monitoring of unassessed lakes on the same rotating schedule. Additionally, where the need exists to assess conditions in coastal embayments and coves, such work could be aligned to occur when the tributaries to these areas are also being monitored. This would foster a more integrated and complete assessment of each watershed unit.

5.6 Fixed Station Network

While DEM plans to shift to a rotating basin approach with respect to baseline assessment of rivers and streams, there remains a recognized need for maintaining more regular data collection from the state's largest rivers. This data is useful in evaluating longer-term trends and variations due to climatic variables. Initially DEM will focus on the state's largest rivers. These rivers constitute the largest tributaries into Narragansett Bay or other Rhode Island coastal waters and are the receiving waters for most of the WWTF effluent discharged into freshwaters. Past monitoring programs have indicated these rivers deliver the majority of nutrient pollutant loadings into Narragansett Bay relative to other smaller tributaries. Historically, monitoring of water chemistry in large rivers had been

conducted by the USGS via cost-sharing agreements with the DEM-OWR. Until October 2002, sampling occurred quarterly in the Blackstone, Pawtuxet, Pawcatuck and Taunton (MA) Rivers. The monitoring involved water column and sediment testing with parameters selected for consistency USGS's national program requirements and protocols.

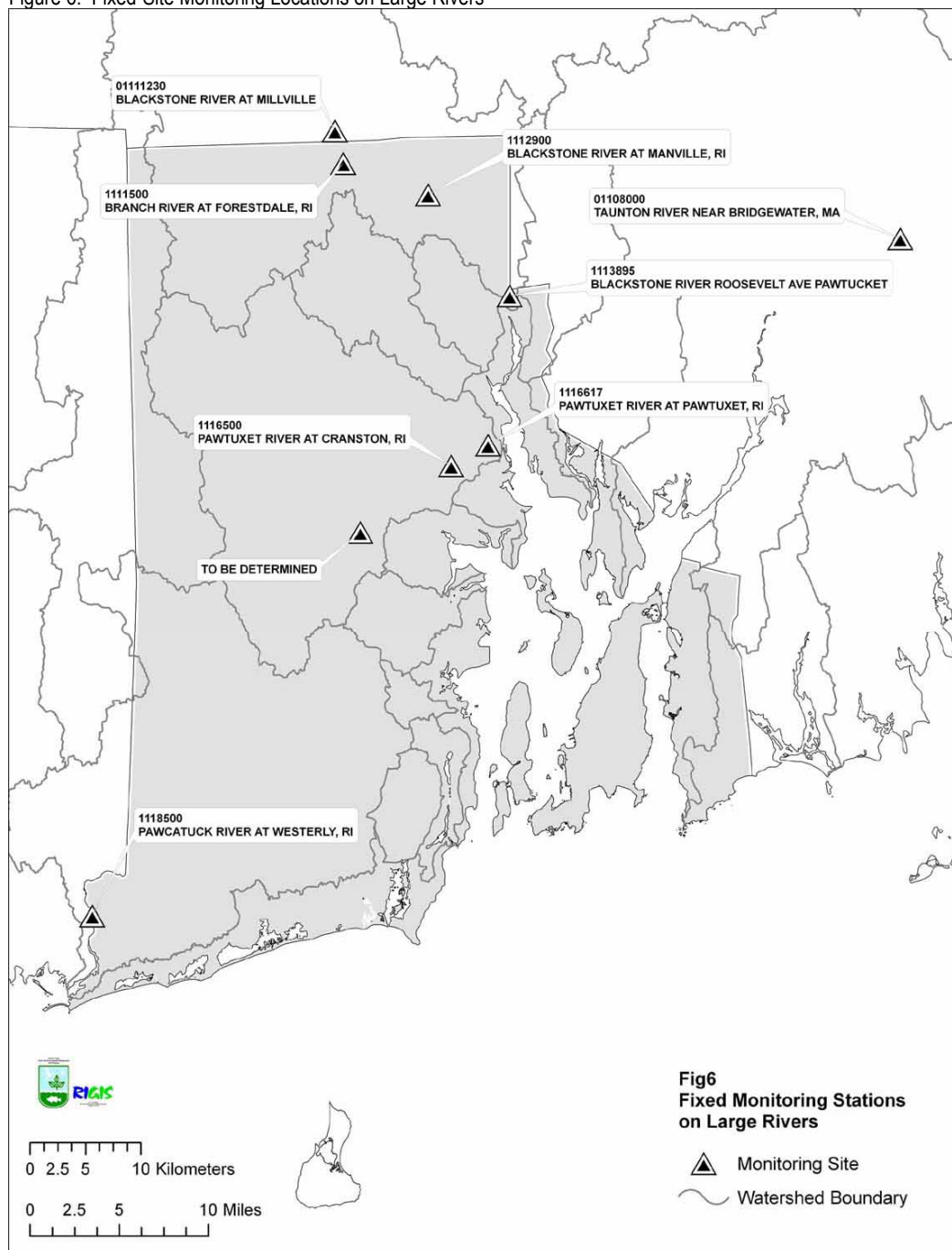
Biological monitoring on the large rivers has also been conducted by DEM-OWR. A senior scientist (biologist) followed an artificial substrate protocol to collect biological (macroinvertebrate) data at the locations USGS was sampling for water chemistry. This work was interrupted by the retirement of the single staff person in the OWR who was trained for this work. DEM needs to replace the biologist and resume data collection.

DEM review of the fixed-stations on large rivers led to a recommendation to restore and expand the fixed station network. A minimum of 9 stations are needed to meet critical data needs including measuring pollutant loadings into the Upper Bay and into the state from Massachusetts. (See Table 10 and Figure 6). The sampling design for this program would initially involve monthly measurements for the core water quality parameters, with quarterly monitoring for metals. Additionally, flow would be measured at each location. However, it is recommended that an analysis of the historical data and other relevant short-term studies be undertaken to evaluate how well the monthly frequency characterizes (1) seasonal variation in nutrient concentrations and loads, and (2) distribution of sampled concentrations and loads across the flow regimes for the sites. Such an analysis may lead to modifying the sampling frequency in cost-effective ways that enhance the value of the data collected in this program. This work should continue via a state partnership with USGS. Additionally, noting that the periodic monitoring associated with the rotating basin approach may have limitations in terms of assessing trends, the number of stations in fixed-station network should be re-evaluated to determine the merit of adding additional stations to improve the tracking of long-term trends. The Taunton River station should be addressed via an interstate agreement.

Table 9. Fixed-site Monitoring Stations on Large Rivers

Site	USGS Fixed Site Sampling Location	Period of Record – Water Quality Data	Rationale for Site Selection	Flow Measure
1	Blackstone River – Millville, MA USGS 01111230	1969-2002	Measures water quality near MA/RI border; allows estimates of contribution of pollutant loads from MA into Blackstone & Bay	Measured day of sampling.
2	Branch River – Forestdale, RI USGS 01111500	1954,1968, 1979-2002	Major tributary to Blackstone	Continuous gage station (1940 – present)
3	Blackstone River – Above Manville Dam USGS 01112900	1970, 1979-2002	Midway in the Blackstone (RI segment) ;downstream of the Woonsocket WWTF	Computed for day of sampling.
4	Blackstone River - Roosevelt Pawtucket USGS 01113895	New 2003 - present	Approaching the mouth of the river; critical for measuring pollutant loadings into Bay	New 2003- present
5	Pawtuxet River – Cranston, RI USGS 01116500	1961-2002	Near mouth of the Pawtuxet; critical for measuring pollutant loadings to the Bay	Continuous gage station (1939-present)
6	Pawtuxet River – Pawtuxet, USGS 01116617	1979-2002	Downstream of Cranston WWTF	Instantaneous at sampling
7	Pawtuxet River – To be determined (new site)	TBD	Upgradient of WWTF influences	TBD
8	Pawcatuck River –Westerly, RI USGS 01118500	1953,1963, 1976 to 2002	Near mouth of the river; measures pollutant loading to Little Narragansett Bay	Continuous gage (1940-present)
9	Taunton River – East Bridgewater, MA USGS	1953, 1967-74, 1997-2002	Near mouth of the rivers; measures pollutant loadings into Mt. Hope Bay	Continuous gage station (1929-1976, 1985-88,1996-present)

Figure 6. Fixed-Site Monitoring Locations on Large Rivers



5.7 Stream Gage Network

As part of a larger process to develop policies concerning water allocation in the state, the Water Resources Board (WRB) organized a Water Allocation Program Advisory Committee (WAPAC) which subsequently organized subcommittees focused on specific topics. One such subcommittee, the Streamflow Subcommittee, recommended in its final report to the WAPAC that a comprehensive streamflow gaging network be developed. A comprehensive stream-gaging program provides hydrologic information needed to help define, use and manage the state's water resources. The data generated from such a network is widely used in water resource programs for purposes related to water pollution control, managing water uses, and drought management. While the WAPAC ended its work in January 2004, the subcommittee continued its work as a joint WRB-DEM Streamflow Committee in order to refine a proposal for a gaging network. The committee issued a report in April 2004 that recommended that the existing network of 20 long-term continuous gages be maintained and that 35 additional gages be activated in the priority order established in the table in Appendix I (DEM –WRB-USGS Streamflow Committee, April 2004). This corresponds roughly to having one gage permanently installed in each HUC 12 watershed area. Currently, the existing gages are maintained by the USGS, with both DEM and WRB contributing to this work via contracts. It is recommended that the contracts be consolidated at the WRB and that they be provided adequate state funding to support the cost-sharing arrangement with USGS. With respect to expansion of the system, initial expansion could target the five gages given 1 and 2 priority rankings, to be followed by the five gages in RI with priority 3 and 4 rankings.

Rhode Island also needs to coordinate with Massachusetts to ensure gages located in our neighboring state that are of importance to resource management in RI are maintained. This should be addressed as part of an interstate agreement.

5.8 Fish Tissue Contaminants

To assess whether RI surface waters are "fishable", as prescribed by the Clean Water Act, DEM relies on fish tissue data and the environmental health risk assessments of such data by the HEALTH Office of Environmental Risk Assessment. As previously mentioned, Rhode Island state government has never sponsored a program to systematically assess fish tissue contamination. The current health advisories regarding fish consumption, issued by HEALTH, are based largely on data derived from other entities, primarily research conducted by the EPA Aquatic Ecology Division at its Narragansett Laboratory. As the current data indicates the degree of contamination is variable, it is difficult to extrapolate results from one river to another. Accordingly, DEM is recommending that fish tissue be assessed systematically within the rotating basin approach.

Given the expense of such monitoring and the persistent nature of the contaminants, such as mercury or PCBs, it is proposed to phase in the program by initially sampling a portion of each watershed included in the rotating basin assessment. Under this approach, it may require 2, possibly 3, rotation cycles (up to a 15 year period) to cover the entire state. The fish tissue sampling design would select a sub – set of the locations being sampled in a watershed under the rotating assessment. Based on the Wood River Demonstration Project, it is estimated that 6-10 sites per basin would be needed to initially monitor the larger streams that draw the most fishing activity. The specific design for fish tissue monitoring will focus on larger streams and exclude first order streams unless downstream data indicate a pollution problem. Under this approach, it is estimated that up to 20-24 locations will need to be sampled in the first cycle (allowing for some follow-up verification sampling). Initial targeted locations would be those sites judged to be the most heavily fished or presenting the greatest potential for public health risk. The parameters at minimum would include mercury, PCBs, cadmium, lead, arsenic and chlordane. Dioxin, an expensive parameter, and other metals would be added on urban rivers and at other sites where past land use or pollution events indicated its potential presence. It is expected that up to 5 species of fish would be sampled at each location. The number of samples targeted for the second and third basin cycles will be influenced by the results of the initial screening.

Implementation of a systematic fish tissue sampling program will require an investment of new resources. With respect to the field collection of samples, options for implementing the design cost-effectively include: (1) contracting for the work; and (2) add 1/2 FTE DEM staff person and support for seasonal interns. In both cases, there may be opportunity to work with volunteers to collect specimens provided there is professional oversight of quality assurance. This might reduce the labor cost of sample collection over the long-term depending on the scope of the program. Tissue sample analysis would have to be contracted to a laboratory. Interpretation of the data would continue to be done by the HEALTH Office of Environmental Risk Assessment. Fish consumption advisories would be generated and updated as needed.

5.9 Sediments

A long-term monitoring strategy for sediments in freshwaters will be incorporated as a future revision to this strategy.

5.10 Recommended Program Enhancements – Rivers and Streams

- Institute a rotating basin approach to ambient monitoring and assessment of river and stream water quality. The approach would incorporate biological, physical and water chemistry parameters. – *pilot projects underway, requires resources to be fully implemented*
- Resume monitoring of selected fixed stations on the state's largest rivers: the Blackstone, Pawtuxet and Pawcatuck. The recommended number of stations includes 7 existing and 1 new location. Increase the frequency of monitoring to monthly for nutrient parameters.
- Re-institute biological monitoring at the fixed-stations on deep rivers.
- Insure that the Taunton River, which provides the largest volume of water into Mt. Hope and Narragansett Bays, is adequately monitored by Massachusetts DEP or other appropriate entity.
- Establish a fish tissue contamination program that is integrated with the rotating basin approach. Sample a portion of the river and stream locations using a targeted sampling design during each cycle, initially emphasizing larger rivers and streams. –*Pilot project will be undertaken in 2006*
- Expand the network of flow gages in the state consistent with plans being developed by the Water Resources Board (WRB). As an initial step, add the five gaging stations given priority ranks of 1 and 2 to the state cooperative agreement with USGS.

6.0 Lakes and Ponds

6.1 Description of the Resource

DEM has mapped 20,917 lake acres in Rhode Island at a scale of 1:24,000. This includes 148 lakes or reservoirs of 20 acres or more in size and hundreds of smaller ponds. Lakes in RI can be characterized as small and shallow, excluding the kettleholes that dot the state, and a number of lakes that are actually reservoirs or impoundments of riverine systems. Most of the impoundments were formed with the development of man-made dams. Among the reservoirs, 42 are designated as public drinking water supply sources, representing 7,813 acres or 37% of the total lake acreage. There are no major WWTF discharges into lakes in RI.

6.2 Monitoring Objective:

- All lakes of 20 acres or greater will be fully assessed for aquatic life and recreational uses by 2011.
- Fish tissue contamination will be assessed in all lakes of 20 acres or greater by 2020.
- Initiate systematic tracking of the extent of aquatic nuisance plants.
- Provide data to allow measurement of water quality trends over longer periods of time.
- Provide data to track trends in the abundance and distribution of freshwater and anadromous fish.

6.3 Background on Current Monitoring Programs and Gaps in Data Collection

The primary source of monitoring data concerning the condition of ponds and lakes is the University of Rhode Island Watershed Watch Program. Initiated in 1987, the program is a professionally supervised volunteer monitoring program that has steadily grown over the last decade. The valuable data generated through this program supports lake assessments by DEM. As a result, in 2004, DEM was able to report that only 20% of lake acres were unassessed. The program coordinates the training of volunteers and the subsequent field collection of samples from lakes for a seasonal period running May through October. The data collected supports assessments of aquatic life and recreational uses and is used for classification of the trophic status of the lake. The program does not currently address toxic contaminants.

In 1999, DEM-OWR entered a five-year agreement with URI-WW to support the expansion of the number of lakes monitored. As of 2004, the total number of freshwater lakes and ponds in Rhode Island actively monitored under the program was about 80, with 68 of the lakes being 20 acres or greater. A total of 34 entities contributed to the cost of executing the program through sponsorship in 2004. While the program does experience a lake being dropped from the program on occasion due to volunteers leaving the program or a lack of sponsorship to support program costs, it has been successful in building long-term data sets on lake water quality conditions that can support trend analysis.

Other sources of water quality data on lakes are the HEALTH bathing beach and drinking water programs. The bathing beach program collects pathogen data from licensed beaches on freshwater lakes and ponds. The HEALTH Drinking Water Quality Program obtains data on 31 terminal reservoirs, all over 20 acres in size. Additionally, DEM solicits and receives some data directly from local water suppliers that may be used to assess other waterbodies in the drinking water supply watershed for recreation and aquatic life uses.

After all sources of data are considered, DEM has determined that there are 46 lakes and ponds of 20 acres or greater that are not regularly monitored in the state.

Another large data gap concerns toxics. As with rivers, due to a lack of an established fish tissue contamination program, the data available is derived primarily from EPA research and special project studies. Only about 2% of all lake acres were assessed for fish consumption (2004 305(b) report.) Additionally, there is a gap with respect to the presence of toxics in the water column, including metals , pesticides, etc.

With respect to lakes, there is a growing recognition of the need to improve policies and programs to address concerns about aquatic nuisance plants. Bioinvasives are also a concern. To support this effort, it would be beneficial to have data on the extent of both problems. With respect to aquatic nuisance plants, tracking the treatment or other measures used to abate nuisance weeds is also important in order to assess downstream impacts on water quality and biota.

6.4 Sampling Design – Volunteer –Based Lake Monitoring

DEM plans to continue to collaborate with URI-WW on baseline monitoring of lakes. The URI-WW program conducts a seasonal sampling program that incorporates physical and chemical parameters as well as pathogens. (See Table 10.) This provides adequate data from which DEM can make assessment decisions with respect to aquatic life and recreational uses. The sampling location is usually in the deepest portion of the lake. Given the biological response of lakes to variations in the weather, one year of data is not always considered representative of the general condition of the lake. Assessment decisions are enhanced when based on several years of data.

Using GIS, DEM has determined there are 148 lakes of 20 acres or more in size in the state. This will serve as the initial target for assessment with smaller lakes and ponds of interest added as resources allow. DEM believes there are currently 46 lakes of 20 acres or more that are not monitored regularly. To address this gap, DEM plans to work with URI-WW to continue to: (1) recruit volunteers for these lakes and (2) establish a two-person team to conduct monitoring in those lakes for which no volunteers are recruited. Where feasible, DEM will align the initiation of sampling in unassessed lakes with the rotating basin approach.

Table 10. Water Quality Parameters Measured in URI-WW Program for Lakes

Water clarity (Secchi depth)	Chlorophyll (lakes and ponds)
Water depth	Total and dissolved Phosphorus
Temperature	Total, nitrate-, and ammonium- Nitrogen
Dissolved Oxygen (deep sites)	Chloride
pH	Fecal coliform and <i>E. coli</i> bacteria
Alkalinity	

6.5 Sampling Design - Small Ponds

During the first five years of this strategy, DEM will focus on expanding the monitoring of larger lakes and ponds (those over 20 acres). Recognizing that smaller ponds comprise a portion of the state's total lake and pond acres, DEM will in the future develop a separate strategy for assessment of those ponds. Given the number of ponds in this category, a randomized design may be appropriate.

6.6 Bathing Beaches

The HEALTH Bathing Beach Program provides data that DEM uses to assess the recreational use of lakes. The program for freshwater beaches should be enhanced to be comparable to the level

of activities conducted for the saltwater beaches by incorporating a risk-based approach to monitoring. This will improve the data from which water quality assessments are made.

6.7 Fish Tissue Contamination

DEM is recommending that all lakes over 20 acres be sampled over the next ten years of the rotating basin approach with priority given to those most actively fished or threatened by past and present pollution sources. This work should be coordinated with the fish tissue work being planned for rivers. It could involve either contracting for the monitoring (10 lakes per year on average) or providing staff to execute the work. Minimum parameters to be analyzed will be mercury, PCBs, cadmium, lead, arsenic and chlordane. As with rivers, it may be possible to integrate volunteers into the program provided there is professional oversight. Additionally, DEM would coordinate with the HEALTH Office of Environmental Health Risk Assessment regarding the interpretation of data and issuance of fish consumption advisories.

A separate sampling design will be developed to address small ponds (those less than 20 acres) with consideration given to a randomized design.

6.8 Aquatic Nuisance Plants and Bioinvasives

A strategy for monitoring the aquatic nuisance plants and bioinvasives in lakes and ponds is needed. It will be the subject of a future revision to this strategy.

6.9 Drinking Water Supply Reservoirs

HEALTH regulations require terminal reservoirs be sampled in accordance with drinking water program requirements. Upgradient reservoirs are not routinely sampled. In terminal reservoirs, the monitoring entails a list of over 100 parameters that reflects the compounds for which maximum contaminant levels (MCLs) have been established for *finished* drinking water. Samples are usually collected from one location near the intake to the drinking water treatment plant.

6.10 Sediments

A long-term monitoring strategy addressing sediments in freshwaters is needed. It will be developed as a future revision to this strategy.

6.11 Recommended Program Enhancements - Lakes and Ponds:

- Expand the URI-WW Program to allow unassessed lakes to be periodically monitored and assessed.
- Establish a fish tissue contamination program that is integrated with the rotating basin approach. Sample a portion of the lakes within a basin for three rotation cycles. - *pilot project will be undertaken in 2006*
- Develop a strategy for monitoring the extent of aquatic nuisance plants in lakes and ponds and for tracking the treatment or management actions undertaken to abate nuisance plants. This action should be undertaken in conjunction with establishing a lake management program in DEM.
- Develop a strategy for monitoring the extent of bioinvasives in lakes and ponds..
- Expand resources for the HEALTH Bathing Beach Program to allow improved assessments of water quality at freshwater beaches.

7.0 Data Definition and Quality Assurance

7.1 Quality Management Program

Quality assurance is an important component of the major monitoring programs relied upon by state water protection programs. It is important to ensure that the data generated by monitoring and used to support decision-making in water protection programs is valid and appropriate. All state monitoring programs should have written quality assurance plans that address how the quality of data is assured.

With respect to its environmental regulatory functions, DEM operates consistently with an approved agency-wide quality management program (QMP). DEM's program was initially approved by EPA in 2002 and updated in September 2003 & 2005. The program outlines policies and procedures to ensure the scientific validity of data, including water quality data, collected via various programs. The plan, which is federally mandated, is available on the DEM website. A QMP for HEALTH was approved in June 2005.

Within DEM, with respect to ambient monitoring programs and water quality investigations performed for the TMDL program, quality control and assurance is generally implemented in a de-centralized manner with each monitoring program or project conducted in accordance with a specific quality assurance project plan (QAPP). QAPPs need to be developed by professionals with the appropriate expertise. They are developed by DEM-OWR staff for monitoring activities conducted in-house; e.g. in the TMDL program, a QAPP is developed for each specific water quality investigation. Where DEM is funding monitoring activities outside of the agency, DEM requires via contract language and grant agreements that its contractors or partners develop the necessary QAPPs prior to data collection. In that process, DEM will review and comment on draft QAPPs prior to their being finalized. To comply with EPA regulations concerning the use of federal funds for monitoring, it is necessary for final QAPPs to be submitted to and approved by the EPA Regional Laboratory Quality Assurance Officer. DEM also maintains copies of QAPPs in the OWR. DEM has not yet developed the capacity internally to institute a QAPP review and approval process at the state level. If resources allowed, it would be advantageous for the entities involved in monitoring in Rhode Island to have DEM, alone or in collaboration with URI, to develop such capacity. If local capacity for water quality monitoring is to expand, the state will need to provide assistance on matters of quality assurance if local or watershed-based organizations are interested in having their data utilized in the assessment process. One advantage inherent in the URI Watershed Watch Program is that the program provides its volunteers with access to professional oversight that addresses many quality assurance requirements. A list of the current status of approved QAPPs for key ambient monitoring programs is in Table 11.

Not all monitoring programs operate with QAPPs oriented to EPA guidance. For example, the fisheries and shellfish growing area programs operate in accordance with guidance or protocols issued from other federal agencies. DEM may receive and use data from such programs, but is obligated to document quality assurance if the data is relied on in making decisions in the assessment of water quality conditions. Where such data is being used by the state, DEM will continue to make efforts to ascertain and, if needed, encourage procedures that properly document quality assurance. Where quality assurance can not be documented or has not met minimum requirements, the data will given less weight or may not be deemed valid in the DEM assessment process.

Table 11. Status of Quality Assurance Plans in Monitoring Programs Used for Water Quality Assessment

Monitoring Program	Agency conducting sampling	Status of QAPP/Comment
Baseline Water Chemistry – Rivers (Wood River Pilot Project)	URI-CEE (DEM contractor)	EPA approved (2004)
Macroinvertebrate Sampling-Wadeable Streams	ESS Group (DEM contractor)	EPA approved (2002; updated in 2003 & 2004)
Artificial Substrates – sampling in deep rivers	DEM-OWR	Needs to be developed.
Shellfish Monitoring Program	DEM-OWR	Compliant with NSSP and ISSC. (EPA approval not applicable). Standard operating procedures developed.
Fixed-station network – Narragansett Bay	URI-GSO, DEM-OWR, NBNERR, NBC, RWU	Under development for submittal to EPA. Plan intended to be used by all participating agencies. Documentation of QA currently varies among agencies.
Bathing Beach Monitoring – Coastal beaches	HEALTH	EPA Approved (April 2003)
Bathing Beaches Monitoring-freshwater	HEALTH	EPA approval not applicable. Standard operating procedures developed.
Volunteer Monitoring	URI-WW	EPA Approved (June 2005) – Laboratory Under EPA review - field procedures
	Blackstone River Coalition	EPA Approved July 2004
TMDL Water Quality Investigations	DEM- OWR & its contractors	Approved on a project basis.

7.2 Data Quality and Measurement Quality Objectives

Data quality objectives (DQOs) are important to ensuring that the quality and quantity of data collected is appropriate for its intended use. Each monitoring program should establish DQOs as part of developing the sampling design and associated quality assurance plans. Pursuant to EPA guidance, the process of developing DQOs defines the questions that a data collection is intended to address, what decision-making process will be used with the data and the level of uncertainty that is allowed in making these decisions. (EPA, 1994a) This helps ensure that investments in monitoring are yielding data that is productively used in state programs. QAPPs also specify data quality measurement objectives which indicate the level of accuracy in the analyses of the samples; e.g. confidence level. Recently developed QAPPs require documentation of DQOs, while older sampling plans may be less specific. DQOs should be periodically reviewed to help ensure that monitoring programs are both cost-effective and meeting the data needs of adapting management programs.

7.3 Quality Assurance/Quality Control (Standardization of Methods)

With respect to the assessment of surface waters on a statewide basis, the small size of the state works to Rhode Island's advantage in that the key baseline monitoring programs have typically been applied statewide. Compared with larger states, this minimizes issues with comparability of data and promotes consistency within the assessment process given that waterbodies are being evaluated using data from the same source.

There are programs in which standardization of methods is still a focus of attention. Most notably, the agencies participating in the fixed-station network are continuing to work toward a set of common standard operating procedures (SOPs). This includes developing common procedures for equipment calibration, operation and maintenance as well as data management; e.g. editing, correction etc. Once accomplished, this will reduce concerns about the comparability and validity of data being generated.

Another area that needs further review concerns data collected in other states. For example, methods for data collection in Massachusetts need to be reviewed to ascertain compatibility with Rhode Island data and support aggregation of data across the entire watershed.

Over time the RIEMC should review this topic and determine whether there are any additional areas where improved standardization of methods is needed.

7.4 Recommended Program Enhancements – Quality Assurance

- Complete work underway to develop a common standard operating procedure (SOP) for the fixed-station network deployed in the Bay. – *In progress*
- Document SOPs and quality assurance plans in other monitoring programs where needed.
- As quality assurance plans are updated, identify and clarify data quality and measurement objectives for those monitoring programs relied upon by state resource managers.
- Further develop the capacity to provide assistance to local entities and others interested in developing QAPPs for their monitoring programs.

8.0 Data Management and Analysis

8.1 Introduction

Data management must be an integral part of all monitoring programs relied on by state water resource managers. It has been noted that all monitoring programs should “include plans and resources for ongoing data synthesis, analysis and reporting to all audiences in a prompt and reliable fashion”.(GNBWPC, 2004) As highlighted previously, it is the critical task of analysis and interpretation that translates raw data into meaningful information. When this step is minimized or not even undertaken, it increases the likelihood that the data will not be made accessible or productively used and the investment of resources in collecting the data rendered a waste.

Reflecting the recent state mandate, the long-term goal of this strategy is to develop a data management system that meets the needs of state water programs while at the same time supporting integrated data analysis and facilitating access to data and assessment information. DEM is currently developing major data systems improvements that when accomplished will mark substantial progress toward achieving this goal. However, in order to ensure data systems are integrated or linked appropriately across multiple agencies, additional evaluation of current data management practices, agency capabilities and future requirements is needed. Such an evaluation will produce additional specific recommended actions that will need to be implemented over time as monitoring programs are enhanced. At this point in time, this section describes the data systems that support current key water monitoring programs, described enhancements underway and identified additional steps that are needed to further enhance and improve data management.

8.2 Overview of Current Data Management Practices

Data management and analysis activities are currently decentralized and dispersed among the agencies and entities engaged in monitoring. This is true both within agencies, among agencies and among the different levels of government. Over the years, there have been numerous discussions among water agencies about the feasibility of developing a shared water database at the state level. Despite these efforts by DEM, HEALTH and WRB, as well as the early efforts of the Narragansett Bay Project (NBP) to build a central data warehouse, data today is primarily managed through separate, program –specific databases. Monitoring data is increasingly, but not always, stored in electronic formats. It is used largely within individual programs. Within state government, there is no organized system to compile data across programs and archive data over time. The data management practices of programs vary widely and electronic data sharing is limited by the compatibility of different agency data systems. Most programs are focused on current issues and older data in many cases is not available in electronic formats. Mechanisms to integrate and synthesize data across programs are not widely institutionalized.

Recognizing that environmental managers and policy –makers need access to timely, accurate and consistent data that present a holistic picture concerning water resources, as well as the environment as a whole, the EPA and states have developed a Environmental Information Exchange Network (Exchange Network). The Exchange Network provides an efficient solution to the exchange of environmental data. As further described later in this section, DEM is developing the capability to participate in the network which is national in scope and already in active operation in 42 states.

8.3 Data Management to Support Water Quality Assessment

DEM-OWR has developed a system of databases, organized to work with GIS, that currently supports its function of assessing water quality but clearly needs to be enhanced in order to continue to meet program requirements. Three key databases are managed as part of the system. Databases, known as WQUAL and BIOQUAL are intended to house raw monitoring data from multiple sources in support of the water quality assessment process. Data is compiled and entered, either electronically or manually. WQUAL, a DEM developed Access database, stores

physical and chemical water data. It has been customized to allow comparison of data to Rhode Island water quality standards and is used to identify those waters that may be degraded. BIOQUAL is a more recently developed database that performs a similar function with respect to biological data, in particular macroinvertebrates and fish assemblage data. Both databases are designed to assign data to individual bodies of water which all have been designated with waterbody identification numbers (WBIDs). In the case of large waterbodies, it may be segmented with several waterbody identification numbers for greater precision. The WBID provides a link to the DEM's Geographic Information System (GIS), using ArcInfo. This creates a valuable and essential tool for mapping and analyzing data. For example, it allows data to be sorted and displayed by watershed. The GIS capability is currently being enhanced through a project that will define the relationships between waterbodies in terms of their place in the watershed. Known as the National Hydrographic Dataset (NHD), it will link Rhode Island waterbodies to a reach indexing system for freshwaters that will over time make it much easier to search multiple datasets and develop applications such as selecting for all streams upgradient of a certain river reach.

Not all data compiled by DEM is entered into WQUAL or BIOQUAL and the capacity of the system has become an issue. The databases do not yet incorporate time series data that consist of voluminous data points. DEM has planned a project to develop a new database, using Sequel, which will address the capacity concern, support multi-users, reduce security concerns and eventually accommodate data logger datasets. It will replace the current version of WQUAL and facilitate uploads of data to the national STORET system. The current scope of this project will result in integration of the shellfish program data electronically and create links with HEALTH data systems to facilitate data transfer or access.

The third database is known as the assessment database (ADB) and is used to store information on the assessment status of a waterbody. Provided by EPA, it runs in Access and is being modified to reflect the EPA's new guidance on the water quality assessment process. The ADB is used to calculate the percentages of state waters that support their designated uses. Maintaining ADB is critical to DEM complying with EPA reporting requirements. The database includes summary reports that describe the assessment of the waterbody and explain how impairments were identified. This interpretation of known water quality data on a waterbody specific basis is the type of information most frequently requested by the public from the program.

Table 12 summarizes some basic information on the data management systems for the programs generating the majority of data used by DEM to assess statewide water quality conditions. A more comprehensive inventory of data management practices will be needed to further enhance the data system operating in RI. Additionally, for datasets not yet available via the internet due to a lack of serving capacity, the RIEMC can facilitate the posting of such data via existing web servers provided adequate documentation of metadata.

8.4 Geographical Information System (GIS)

The Geographic Information System (GIS) is essential to the organization of current state water data systems. It provides the tool to integrate data by linking data from various sources to locations established as latitudes and longitudes. Locations can then be assigned to specific waterbodies, based on DEM's WBID system, as well as watersheds. The DOA functions as the GIS administrator for entire state, maintains the existing data layers and is responsible for generating new data layers, as feasible. Agencies, such as DEM and HEALTH, also employ staff to support their internal GIS needs. There is a GIS Steering Committee that meets regularly to address system management and program development.

Table 12. Data Management Practices within Monitoring Programs Used for Water Quality Assessment

Table 12: Data Management / Access within Monitoring Programs for Water Quality Assessment						
Agency/Program		Database Description – raw data	Data Analysis Performed	Web access to data	Transfer of Data to DEM-OWR/ Assessment Program	Entered in DEM-OWR Databases/ Assessment Files
Rivers & Streams						
URI- CVE –water chemistry		Excel spreadsheet	yes	no	Electronic; annual summary	WQUAL
ESS Group – macroinvertebrates		Excel spreadsheet	yes	no	Hardcopy; electronic is available	BIOQUAL - pending
USGS – water chemistry			yes	yes	Hardcopy	WQUAL
DEM- artificial substrates		Hardcopy files	yes	no	Hardcopy	BIOQUAL
URI – WW – tributary streams		Excel; Access	yes	no	Electronic	WQUAL
Lakes						
URI-WW - lakes		Excel; Access	Yes	no	Electronic	WQUAL
Coastal Waters						
Fixed Stations						
	GSO	YSI EcoWatch; export to Excel	Yes	Yes*	Electronic; direct daily access & annual summary	To be determined
	NBC	YSI EcoWatch; export to Excel	No	Yes	Electronic; via web	To be determined
	NBNERR	YSI EcoWatch; export to Excel	Yes	No**	Electronic; on request; data compilation, quality assurance for all stations for 2004	To be determined
	DEM-OWR	YSI EcoWatch; export to Excel	Yes	Yes	Electronic; direct daily access	To be determined
DEM-Shellfishing		Excel/Access	Yes	No	Electronic	WQUAL
Other Programs						
TMDLs		Excel	Yes	No	Hardcopy of data summaries	Filed hardcopy
HEALTH – Bathing Beaches		Web application; exports to Excel.	Yes	Yes	Electronic	Filed hardcopy

* DEM access to raw data is provided by a restricted file-sharing mechanism. A summary of data (daily averages) is posted publicly to the web.

** NBNERR submits raw and edited data to the NERR Central Data Management Office for secondary review and archival on the web.

8.5 STORET

STORET is a national water quality database, developed by EPA and designed to serve as a national repository for water quality data. Within its Clean Water Act jurisdiction, EPA is requiring that data be reported to STORET. Historically, DEM-OWR did not have the technical capability of operating STORET and as a result the system has not been used within water programs. EPA has continued to modify STORET and it is now available in a version that can be acquired and maintained via a PC Oracle license within the configuration of DEM's current data management systems. With assistance from an EPA technical contractor, DEM has examined the feasibility of uploading data to STORET and determined that the most efficient approach will be to accomplish uploads via the Exchange Network. DEM has committed to beginning initial data uploads by 12/06 contingent on successful development of a node to support connection to the Exchange Network.

The Exchange Network allows partners (DEM and others) to map data to XML schema – a universal language—and then send or publish that data with web services via a node (designated server). The Node is a secure server that is the exchange point for all data submissions and requests. The node allows a flow of data using common data structures and formats. The new DEM water quality database will be capable of producing formatted data flows that will upload to EPA's STORET data warehouse.

Integration of STORET into DEM's data management systems is envisioned as providing a single means for all programs contributing data to the water quality assessment process to comply with EPA's requirements regarding STORET. Given the complexity of the system, in particular controls over what can be entered, DEM does not believe it will be reasonable or cost-effective in the short-term for most of its monitoring partners to engage directly with STORET. Rather, it is DEM's goal to work with partners over time to ensure data is provided to the state in a form that will allow entry into STORET via the Exchange Network. DEM will need to dedicate staff to support this function.

The HEALTH Bathing Beach Program has developed a data system that allows upload of data into STORET.

8.6 Data Synthesis and Integration

While state agencies synthesize water data in various ways to support program purposes, mechanisms to support data integration more broadly have generally been lacking. With the establishment of environmental indicators, data can start to be organized, presumably on a watershed basis, to support reporting on the key indicators in a more integrated fashion. Additional evaluation needs to be undertaken to determine the best means to accomplish this task. Programs need to identify where sharing data will enhance their programs; e.g. the water quality assessment program expects to benefit by application of freshwater fisheries data to the assessment process over time. In some cases, more research is needed to develop tools that allow water management programs to make effective use of additional datasets; e.g. land use and its relationship to water quality. There are projects or programs that aim to accomplish synthesis of data. These include: (1) the NBNERR has compiled various datasets concerning Narragansett Bay and developed a GIS application designed to provide easy access to the information for users including emergency response personnel, (2) the Bay Window Program plans to devote resources to integration of the datasets generated in its program, and (3) DEM-OWR integrates various data sources in its assessment process in accordance with its CALM. However, further review of most appropriate way to accomplish data synthesis is needed by management agencies and the RIEMC.

Relative to Narragansett Bay, the CI and NBEP, working with others, should continue to play a leading role in fostering improved data synthesis and integration with respect to reporting on trends in the ecological health of the Bay. Ensuring an appropriate level of integration should be part of the overall data management plan that is developed to complement and support this strategy. The long-term goal should be to bring together information on water quality, biological resources (fisheries), habitat, land use and pollution sources to define the condition of the resource based on an appropriate set of environmental indicators.

8.7 Dissemination of Monitoring Data and Assessment Information

State law has specified a goal for sharing and disseminating data to support the overall function of monitoring with the internet playing an important role. The RIEMC should examine this topic and make further recommendations on how best to accomplish dissemination of data – and assessment information- to various interested parties. In the short-term, the URI website, designed to provide links to databases, should be updated. Various agency websites should be linked where appropriate. Several of these currently provide access to data.

State agencies are required to submit data and information in different reports to EPA, NOAA and other oversight agencies. DEM periodically reports on statewide water quality conditions as part of its obligations under the Clean Water Act. Statewide assessment is currently completed every two years with a less extensive update required for

the intervening year. DEM is completing a 2004 report and will report in the new assessment format in 2006. Reports and assessment information is made available via DEM web-site and distributed via public libraries.

8.8 Recommended Program Enhancements – Data Management

- Through the RIEMC, initiate further evaluation to identify data system improvements and needed to support a comprehensive environmental monitoring program, including dissemination of data.
- Develop a node capability to allow state participation in the Environmental Information Exchange Network to facilitate transfer of data including uploading of water data for archiving in STORET. - *In progress*
- DEM should continue to update the databases used for water quality assessment process as needed including planned upgrade of WQUAL. – *In progress*

9.0 Implementation Schedule & Resources Needs Assessment

9.1 Overview

A core set of resources including personnel, equipment, facilities, and logistical support is needed to effectively implement the comprehensive monitoring and assessment programs envisioned by this strategy. Given the gaps in the current programs, a phased approach to implementing this strategy has been proposed in order to realistically build capacity and develop new programs where needed.

The actions outlined in this strategy include implementation of existing programs, program enhancements, several new initiatives and continued work to develop and refine specific monitoring programs. The strategy builds upon the existing capabilities of entities engaged in monitoring and acknowledges that there options with respect to how certain programs are implemented, specifically whether work is conducted by state personnel or accomplished by partners or contractors via agreements with the state.

Within the DEM-OWR, given the responsibility for water monitoring and the planned expansion of activities, there is clear need to dedicate a person to coordinate ambient monitoring programs. This person would be responsible for coordinating the rotating basin approach as further described below and providing direction for and oversight of all other DEM-OWR baseline monitoring efforts. This would include management of the various contracts and agreements that the DEM-OWR maintains with its partners and vendors. A monitoring coordinator will be critical to strengthening and effectively implementing the key baseline monitoring programs that support the water quality assessment process.

9.2 Implementation Schedule & Estimate of Needed Resources

Tables 13A-E outline an implementation schedule for the actions recommended in this strategy. It is important to note this includes a timeframe for revising and updating the strategy to include other water –related components. Pursuant to state law, a strategy will be updated every three years as part of the work of the RIEMC. The schedule also notes when certain required reports must be made including the Integrated Report, which summarizes the state assessment of water quality conditions and is submitted to EPA.

Table 14 contains information on the cost of implementing the recommended monitoring programs in the short-term. The Table provides estimates of funding committed in the current state fiscal year (2006) as well as projects the funds needed for the upcoming state fiscal year FY2007 (7/1/06-6/30/07). The last column estimates shortfalls in available funding for 2007. *Note: Estimates for related recommended actions from Tables 14D & 14E have not yet been incorporated, but will be added in a future revision.*

For the recommended field monitoring programs, a total of \$5.47 million will be required in FY2007. An estimated \$3.48 million is expected to be available in state and federal funds leaving a shortfall of about \$1. 98 million.

9.3 Implementation Issues

The following provides details regarding the implementation of specific recommended monitoring activities deemed *high* priorities:

Fixed-site Monitoring Network in Narragansett Bay: It is a *high priority* to sustain the fixed-station network in Narragansett Bay to monitor ambient water quality conditions in a period of expected change due to nutrient reduction strategies. Rhode Island has been able to capitalize on the availability of federal funds to acquire the instrumentation and related equipment that supports the existing network. Due to its development, the network is operated by multiple agencies. The expansion of the network from 10 to 13 sites was largely funded from the Bay Window Program during the 2005 sampling season and implemented via DEM contracts. Operation of the network

needs to become institutionalized within DEM and supported with a reliable source of funding to sustain its operation over the long-term. Of the 13 stations operating in 2005, only those operated by NBC (two stations) and NBNERR, within its reserve monitoring program (2 stations), expect to have reliable funding for deployment and maintenance in 2006-2007. While DEM will continue to pursue federal funds (NOAA Bay Window), operation of the majority of the network, including several critical stations in the upper Bay and Greenwich Bay, will be jeopardized in 2007 unless a commitment of funding is made to sustain the program. Two fulltime equivalents, with seasonal support, are needed to execute the work necessary to prepare, deploy, operate and maintain the remaining stations as well as accomplish data management tasks. Stations are generally visited every two weeks and protocols require calibration of instruments both the day before and day after the field inspection. Although telemetry equipment will be utilized at some stations to provide near-real time access to data within DEM, there are components of the stations (sondes) that must be exchanged regularly (typically every two weeks) in order to produce valid data. DEM-OWR will continue its role of coordinating the network and for critical stations in the upper Bay, ensure routine review of data during the sampling season. It will also take on responsibility for ensuring that data from the entire network is compiled, edited, corrected and made publicly available.

Fixed-Stations on Large Rivers: It is a *high priority* to restore monitoring of fixed-stations in large rivers. The DEM-OWR had maintained a cost-sharing agreement with USGS for quarterly monitoring of seven stations on large rivers until 9/30/02. After this date, DEM no longer had state funds available to support an agreement and monitoring was suspended. Given the long-term nature of the data sets and their importance to trend analysis and measuring pollution loadings into the Bay, it's critical to resume monitoring. DEM plans to increase the sampling frequency. USGS has indicated it may be able to provide a cost-share for the work.

Rotating Basin Approach: It is a *high priority* to institute this new monitoring approach which is essential to reducing the large gap in water quality data for rivers and providing the DEM-OWR with much needed expertise in aquatic biology. The rotating basin approach relies on a team approach to accomplishing the assessment of watersheds. The DEM-OWR has relied on use of contractors to execute pilot demonstration projects. Fully implementing the team approach can be accomplished by adding sufficient staff to comprise the team or adding fewer staff and providing sufficient contractual funds to accomplish the monitoring work. With either option, the active core of a rotating basin study team is comprised of a team coordinator, two biologists (representing each of two organism groups), and one or more water quality analysts (chemical/physical indicators). Additional members of the team should include all relevant aspects of water quality management that are potentially affected by the outcomes of the rotating basin approach. This would most commonly include the RIPDES, WQS, TMDL, and watershed management programs, but could incorporate other programs as needs and issues dictate. In addition, watershed stakeholders may be included depending on their presence and activity within a particular watershed. The goal should be to gain involvement before the watershed assessment is planned and implemented.

The coordinator is responsible for leading all activities of the team beginning with initial planning and coordination with applicable water quality management programs and stakeholder groups, development of a detailed plan of study, coordination of any adjustments to the plan during the field sampling, post-field debriefings, oversight of data analysis, and the synthesis and coordination of an integrated assessment. This position needs to be a part of the DEM-OWR regardless of where the other team members are located. This position will be critical to initiating a new approach and for the related day-to-day coordination responsibilities and functions within the DEM water programs. Furthermore, this position will be critical to disseminating the results of the rotating basin approach both within and outside of DEM at all levels and building and maintaining support for the program.

The biologist positions are needed to provide the expertise to conduct the sampling and analyses associated with macroinvertebrate and fish assemblage assessments. The execution of the DEM biological program will require two full time biologists and 3-4 seasonal interns who assist with data collection during the field season. The areas of specialty and expertise include the sampling and assessment of stream and river macroinvertebrate and fish assemblages. Each requires skill in taxonomy at the level of detail required by the strategy, skill in using standardized sampling methods and procedures, sample processing, data recording, data custody procedures, data

analysis, and reporting and communication. The interns will fulfill the role of providing labor and assistance with the field sampling.

Presently, DEM contracts for all of the macroinvertebrate work. As capacity for biological sampling is developed within DEM, a continued use of contracts may be necessary as part of the transition. Long-term it is preferable to have the key rotating basin team members employed by the DEM. While a second assemblage is not presently an integrated part of the existing river monitoring program, adding fish is desired and would be best be done by adding an FTE dedicated to this purpose in the DEM Division of Fish and Wildlife. Additional seasonal support would also be needed to execute surveys.

Presently, chemical/physical water quality sampling and analysis is largely provided by URI. This arrangement, too, might be workable for the rotating basin approach provided that the functional supervision and day-to-day access needs are met. The skill and professional skills requirements are similar in dimension to the two biological positions and require knowledge in sampling design, use and maintenance of specialized equipment and instrumentation, physical capacity, and data analysis and QA/QC practices.

The team approach is critical to ensuring that the resulting watershed assessments accomplish the tasks of documenting current conditions (relative quality, extent and severity of impairments), providing an integrated assessment of the effects and roles of multiple indicators and stressors, and addressing the use attainability needs identified in each. These are the critical precursors to achieving better permitting, standards, planning, and TMDLs. How it is organized, managed, and implemented is equally important to what is measured and monitored. Furthermore, the custodianship of this process by the study team is critical to its success and will also determine how much improvement is gained in the execution of the day-to-day aspects of the water quality management programs.

Fish Tissue Contamination: It is *high priority* to institute a fish tissue sampling program. The state has never established a fish tissue contamination program. DEM is proposing to phase in sampling in a systematic manner that aligns the work with the rotating basin schedule. Some capacity to conduct follow-up samples is included in the resource estimate. It should be noted that if the initial round of sampling determines a significant amount of contamination, the costs in future years will increase as sampling is targeted further up into the smaller tributary streams of an impaired river. DEM is proposing to initially contract for this work and re-evaluate the cost-effectiveness of such this approach versus other options.

Expansion of Streamflow Gage Network: It is a *high priority* to expand the network of flow gages. Five additional locations, previously ranked highest on a statewide prioritization list should be funded. Contracts for flow gages should be consolidated in a single agency (e.g.WRB) for administrative efficiency.

Rotating Assessments of Coastal Waters & Closed Shellfishing Areas: Institution of this program is a priority for reducing data in coastal waters. Plans for assessing portions of the state's coastal waters that are not regularly monitored will initially require a two-person team (1 FTE with seasonal support). This work, which is a new initiative, coupled with the expanded activities with the fixed-station network will also require that the DEM-OWR acquire a third boat suitable for sampling marine waters. This additional staff would also work with the existing shellfishing staff with respect to expanding pathogen sampling in closed areas and be available to support targeted dissolved oxygen surveys in the upper Bay and other BART/emergency response needs.

Lake Monitoring: It is a *high priority* to maintain this program. The DEM-OWR is in the process of renewing a five-year agreement with URI-VW that supports volunteer-based monitoring of lakes. Expansion to date has been successful to the point that if the program is to continue to significantly expand it will require an additional person to coordinate volunteer-based efforts. Given its important function, the state should provide some base support to provide stability in funding. Additionally, recognizing that volunteers may not be available for some lakes, URI-VW will need additional capacity in the form of a two-person team to address unassessed lakes in the future.

Support for the RIEMC: It is a *high priority* to provide an appropriate level of support to the RIEMC. This is needed to ensure its effectiveness and to allow an expansion of activities that fosters and improves collaboration and coordination among monitoring programs operating in the state.

Data Management: Improving data management systems is a priority. With the use of federal funds, the DEM-OWR is currently making a significant investment in developing the capability to manage water –related datasets. Funding is needed to support further evaluation of needed data system improvements on a statewide basis. It is expected that the review would then outline further investments needs. Funding is also needed to support data synthesis and integration tasks.

Facilities: To implement the rotating basin approach, fixed-station network and other monitoring programs, it was recognized as critical for DEM to improve its facilities to provide adequate storage space for equipment and proper laboratory space in which to conduct work including maintenance of equipment. In Providence at the DEM Headquarters, space has been added and will be renovated for use by the DEM-OWR for bulk storage, secure equipment storage, an area for constructing, maintaining, and repairing equipment, and laboratory space. Indoor storage of most sampling equipment is recommended to extend service life and operability. At the Great Swamp facility, the DEM F&W is planning a new building that will significantly upgrade the laboratory and other space available for freshwater fisheries programs. The DEM-OWR is forecasting the need for another boat to support the expansion of field sampling in coastal waters. Boat storage and docking are issues that will also need to be addressed as implementation proceeds.

9.4 Review and Updates of the RI Water Monitoring Strategy

The RI Water Monitoring Strategy will be periodically reviewed and updated to ensure that it reflects the mix of monitoring programs that is needed to support adaptive management of the state's resources. DEM expects the reviews to be coordinated with the RIEMC especially given the on-going process of refining the broader environmental monitoring framework for the state via the addition of new monitoring activities, e.g. bioinvasives. State law requires the strategy, as part of a broader environmental monitoring framework, be updated every three years. The updates will be communicated via the Coordination Team to the Governor and legislature as well as EPA. Additionally, DEM will on an annual basis review and report on progress in executing its monitoring programs as part of the annual workplan and EPA grant application process. The annual review will note and explain any instances where planned monitoring program targets or milestones were not achieved as well as identify progress above that planned. DEM is currently working on a tracking system to facilitate reporting to EPA on all PPA/PPG grant commitments.

Table 13A. Implementation Schedule – Existing and Recommended Field Monitoring Programs- Coastal Waters

Recommended Action & Agency	FY05 (7/04-6/05)	FY06 (7/05-6/06)	FY07 (7/06-6/07)	FY08 (7/07-6/08)	FY09 & FY10 (7/08 – 6/10)
Narragansett Bay & Coastal Waters					
Fixed Station Monitoring Network Expansion (DEM, NBNERR, NBC, RWU, URI)	Maintain existing network; 3 stations added	Sustain existing network; Re-evaluate expansion needs; add two stations if resources allow	Maintain existing network; Add 2 stations *	Maintain existing network; Add 1-2 stations *	Maintain existing network; Add 1-2 stations *
Rapid dissolved oxygen surveys in upper bay (enhance response capability) (NBEP/DEM/partners)	Add new equipment/train staff; Conduct survey June 2005	Conducts surveys – summer 2005; evaluate results.	Conduct surveys summer 2006; evaluate results.	Evaluate results and refine survey targets; Conduct surveys as needed	Conduct surveys as needed
Rotating assessments of coastal ponds and coves (DEM-OWR)			Refine schedule for rotating assessments in coves and embayments; Acquire equipment & staff	Initiate rotating assessments	Continue assessments
Shellfish Monitoring Program (DEM-OWR)	Maintain program	Maintain program	Add staff to expand sampling	Sustain expanded program	Sustain expanded program
Bathing Beach Program – coastal beaches (HEALTH)	Maintain program	Maintain program	Maintain program	Maintain program	Maintain program
Providence and Seekonk Rivers – Water quality (NBC)	Resume program with modifications.	Maintain program	Maintain program	Maintain program	Maintain program
Pathogen monitoring (NBC)	Maintain program	Maintain program	Maintain program	Maintain program	Maintain program
Marine Fisheries <ul style="list-style-type: none"> • Finfish trawls • Juvenile finfish • Shellfish populations • Lobster populations • Horseshoe crab (DEM-F&W)	Maintain programs	Maintain programs	Maintain programs & expand finfish trawls to RI & BI Sound.	Maintain programs	Maintain programs
Macroalgae Surveys (NBEP/URI/DEM)		Initiate testing of field survey methods	Continue evaluation of survey methods	TBD	
Measure extent of SAVs – (NBEP)		Plan and execute aerial overflight for 2006	Photointerpretation – contingent on resources		
Benthic Monitoring (URI-GSO)	Benthic sampling at Selected stations	Benthic sampling at four stations	TBD		
Circulation & Flows (NOAA/DEM)	Maintain PORTS program	Maintain PORTS; review locations and make adjustments as needed	Maintain PORTS	Maintain PORTS	Maintain PORTS
Fish tissue contamination (DEM-OWR)		Review NCA data and refine strategy	Refine fish tissue sampling strategy for coastal waters		

Fiscal years refer to state fiscal years (July – June)

*Number of stations subject to change based upon continuing review of available data.

Table 13B. Implementation Schedule – Field Monitoring Programs – Freshwater Rivers and Streams

Recommended Action	FY05 (7/04-6/05)	FY06 (7/05-6/06)	FY07 (7/06-6/07)	FY08 (7/07-6/08)	FY09 & FY10 (7/08 – 6/10)
Rivers and Streams					
Fixed-site Monitoring on Large Rivers (USGS,DEM-OWR)		Coordinate with MA & EPA on monitoring in Taunton River	Expand program to 8 recommended sites in RI Resume biological sampling at stations	Sustain programs	Sustain programs
Institute rotating basin approach (DEM-OWR)	Continue sampling program for demonstration project- Wood River;	Complete demonstration project – Wood River; Initiate sampling in selected Pawcatuck River watershed sub-basins.	Devise schedule for rotating basin approach. Hire staff –Monitoring coordinator, water chemistry & aquatic biologist; Initiate assessment. in new basin (2 nd of 7) Complete assessment in sections of Pawcatuck	Initiate assessment in one new basins (3 rd of 7) Complete assessment in 2 nd basin	Initiate assessments in remaining basins – 4 th & 5 th basins in FY09 6 th & 7 th basins in FY10 Complete assessment in 3 rd basin in FY09 4 th & 5 th basins in FY10 6 th & 7 th basins in FY11
Establish fish tissue assessment program (DEM, HEALTH)		Initiate sample collection in Wood & Pawcatuck watersheds	Initiate sampling in new basin (2 nd of 7)	Initiate sampling in new basin (3 rd of 7)	Initiate sampling in remaining basins (4 th & 5 th in FY09; 6 th & 7 th in FY10)
Monitor pathogens in rivers subject to CSO discharges (NBC)	Maintain program	Maintain program	Maintain program	Maintain program	Maintain program
Sustain and expand the network of continuous streamflow gages (USGS,DEM,WRB)			Maintain network. Add five new gaging stations (priorities 1 & 2)	Maintain network. Add five new gaging stations (priorities 3 & 4) Re-evaluate priorities and needs.	TBD Maintain network.

Table 13C. Implementation Schedule – Field Monitoring Programs – Lakes and Ponds

Recommended Action	FY05 (7/04-6/05)	FY06 (7/05-6/06)	FY07 (7/06-6/07)	FY08 (7/07-6/08)	FY09 & FY10 (7/08 – 6/10)
Lakes and Ponds					
Monitor lakes and ponds via URI-WW	Maintain existing program	Maintain existing program	Maintain existing program	Expand program to sample unassessed lakes. Sustain expanded program	Sustain expended program
Establish fish tissue assessment program		Initiate sampling in Wood-Pawcatuck Watershed	Initiate sampling in two new basins	Initiate sampling in two new basins	Initiate sampling in remaining basins
Beach monitoring program	Maintain program	Maintain program	Expand level of effort and sustain program	Sustain program	Sustain program
Drinking Water Supply Program	Maintain monitoring requirements	Maintain program	Maintain program	Maintain program	Maintain program

Table 13D. Implementation Schedule – Strategy Updates and Reporting

Recommended Action	FY05 (7/04-6/05)	FY06 (7/05-6/06)	FY07 (7/06-6/07)	FY08 (7/07-6/08)	FY09 & FY10 (7/08 – 6/09)
Coordination /Strategy Refinements					
Report to Legislature on Comprehensive Monitoring Strategy	Report in January 2005	Report in January 2006	Report in January 2007	Report in January 2008	Report in January 2009 & 2010
Complete Comprehensive Monitoring Strategy	Strategy submitted to Coordination Team (CT)– January 2005; Review by SAC and CT completed by July 2005.	Final Strategy submitted to EPA by 9/05. Refine strategy as directed by CT.	Review Strategy and update as needed	Updated strategy reviewed and approved by Coordination Team; Updated strategy submitted to EPA	
Planned additions to the strategy	Identify needed additions	Planned additions to the strategy: <ul style="list-style-type: none"> Freshwater wetland bioassessment , Nutrients in coastal waters; SAVs; 	Planned additions to the strategy: <ul style="list-style-type: none"> Nutrients in freshwaters (periphyton); Groundwater; Benthic - coastal waters; Sediments in coastal waters 	Planned additions to the strategy: <ul style="list-style-type: none"> Sediments in freshwaters Aquatic nuisance weeds 	
Development of Strategy for Macroalgae surveys		To be determined			
Development of Strategy for Monitoring Bioinvasives		To be determined			
RI Environmental Monitoring Collaborative	Meet as needed	Secure resources to expand activities	Meet as needed TBD	Meet as needed TBD	Meet as needed

Table 13E. Implementation Schedule –Program Development, Quality Assurance, Data Management & Assessment Reports

Recommended Action	FY05 (7/04-6/05)	FY06 (7/05-6/06)	FY07 (7/06-6/07)	FY08 (7/07-6/08)	FY09 (7/08 – 6/09)
Indicators & Assessment					
Refine environmental indicators	Complete review and refine indicator list	Continue development of indicators; e.g. biological indicators – estuarine waters			
CALM	Complete draft CALM document	Refine CALM	Finalize CALM	Update CALM as needed	Update CALM
Conduct water quality assessment process- produce Integrated Report		Completed statewide; generate integrated report	Odd-year update	Completed statewide; generate integrated report	Odd-year update
Develop procedures to implement new DO criteria for estuarine waters	Initiate technical assistance project; review key data sets.	Complete project and assessment of compliance with criteria.	Convene workshop to review results and identify any needed changes in sampling programs	Implement any needed modifications to sampling programs	
Develop freshwater fish IBI		Initiate project to review data	Complete phase I of project; identify future monitoring needs	TBD	TBD
Develop a reference condition approach - macroinvertebrate monitoring		Initiate technical assistance project	Complete project. Identify additional sampling needs. Initiate additional sampling.	TBD	TBD
Develop refined indicators to assess drinking water use				Review results of source water assessments.	
Quality Assurance					
Standard operating procedures & QAPPs		Complete SOPS and QAAP for fixed station network in Narragansett Bay; Complete QAPPs for lake monitoring	Complete QAPPs as needed	Complete QAPPs as needed	Complete QAPPs as needed
QMPs (Quality Management Plans)	Submit HEALTH QMP for EPA approval (done)	Update QMPs as needed			
Review SOPs and identify areas to improve data comparability			Complete review and develop recommendations	Modify SOPS as needed	
Data Management					
Development of data systems plan			Review data systems and develop improvement plan	Complete plan and prioritize recommendations	TBD

Table 13 E. continued

Recommended Action	FY05 (7/04-6/05)	FY06 (7/05-6/06)	FY07 (7/06-6/07)	FY08 (7/07-6/08)	FY09 (7/08 – 6/09)
Indicators & Assessment					
Develop Network Exchange Node capability and implement STORET uploads via the node	Complete technical assistance project to further assess feasibility issues related to data upload to STORET; Finalize plan for providing data to STORET	Develop node for data exchange.	Initiate STORET uploads.		
Upgrade WQUAL database		Complete upgrade of WQUAL			
Data synthesis and integration		Identify unmet needs and develop projects to accomplish data synthesis & integration	Implement data synthesis projects – TBD.		
Update websites to facilitate access to data and assessment information		Review and improve narrbay.org website (in progress)	Complete review of other sites and identify/make needed changes		

Table 15. Projected Resource Needs FY2005-2006

Recommended Monitoring Program	Program Activity	Implementing Agency	Committed Funds FY2005	Committed Funds FY2006	Needed Funds FY2007	Anticipated Funds FY2007	Funding Shortfall FY2007
Coastal and Estuarine Waters							
Fixed-Station Network - Bay	Maintain existing network	DEM, NERR, NBC, RWU, URI-GSO	-\$294,000	-\$347,000	-\$464,000	\$247,000 ^d	\$387,000 ^e (expanded 16 stations)
	Expansion costs-equipment/O&M	DEM	\$151,000	\$130,000	\$170,000		
	Annual Total		\$445,500 ^a	\$477,000 ^b	\$634,000 ^c		
Rapid Dissolved Oxygen Surveys	Existing capability (1 boat/crew)	NBEP, DEM,	\$55,000	\$55,000	\$81,000	\$60,500 ^g	\$42,500
	Expand to 3 boats/crews	NBEP, DEM, TBD			\$103,000 ^f		
Estuarine River Monitoring	New Spring 2005	NBC	N/A	\$45,000	\$45,000	0	\$45,000
Rotating Assessment of Coastal Waters	Initiate New Program	DEM-OWR	0	0	\$250,000 ^h	0	\$250,000
Shellfish Growing Area Program	Maintain program	DEM-OWR	\$268,000	\$285,000	\$302,250 ⁱ	\$302,250	0
Bathing Beach Program –Coastal beaches	Maintain program	HEALTH	See below	See below	See below		See below
Pathogen Monitoring in Providence	Maintain program	NBC	\$23,000	\$37,000	\$40,000 ^j	\$40,000	0
Volunteer Monitoring-pathogens and other parameters	Maintain program – 40 sites	URI-Watershed Watch & volunteers	See Below	See below	See below		See below
Marine Fisheries • Finfish trawls • Finfish juvenile • Lobster • Shellfish • Horseshoe crab • Grass eel	Maintain programs & expand fisheries trawl into RI Sound	DEM-F&W	\$1,315,000	\$1,355,000	\$1,619,200	\$1,337,717	\$281,483
Fish Tissue					No expenses expected until after 2007		
SAVs surveys					TBD		
Macroalgae surveys					TBD		
Benthic Monitoring					TBD		
Tides /Circulation	Maintain PORTS	NOAA under contract with DEM	\$250,000	\$250,000	\$250,000	\$250,000 ^k	0
Subtotal – Coastal Waters			\$2,356,500	\$2,504,000	\$3,243,450	\$2,237,467	\$1,005,983

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Recommended Monitoring Program	Program Activity	Implementing Agency	Committed Funds FY2005	Committed Funds FY2006	Needed Funds FY2007	Anticipated Funds FY2007	Funding Shortfall FY2007
Freshwaters							
Fixed-Stations – Large Rivers	Institute monitoring at 8 stations	USGS	0	0	\$225,000 ^l	\$30,000 ^l	\$195,000
	Biological Monitoring on Large Rivers	DEM	0	(m)	(m)		(m)
Rotating Basin Assessment of Rivers and Streams	Complete demonstration projects- Wood & Pawcatuck basins	DEM-OWR, URI-CEE, ESS Group	\$135,000	\$90,000	\$75,000 ⁿ	\$75,000	0
	Establish basin team & begin assessments in 2 basins	DEM-OWR	0	0	\$435,000 ^o	\$75,000 ^p	\$360,000
Establish fish tissue program	Begin testing in 2 basins – 24 locations	DEM-OWR w/ DOH	0	(q)	\$130,000	\$50,000(q)	\$80,000
Regional Pathogen Monitoring	Maintain program	NBC	\$57,500	\$58,000	\$65,000 ^r	\$65,000	0
Streamflow gages	Maintain existing network	USGS	\$130,000	\$130,000	\$130,000 ^s	\$130,000	0
	Expand by 5 gages	USGS			\$140,000 ^t	0	\$140,000
Freshwater Fisheries – Anadromous	Maintain existing program.	DEM-FW	\$200,000	\$200,000	\$216,000	\$216,000	0
Subtotal – Rivers & Streams			\$522,500	\$478,000	\$1,416,000	\$641,000	\$775,000
Volunteer Monitoring of Lakes, Ponds and Streams	Maintain existing program level of activity – 70 lakes, 50 tributary streams, 30 river sites	URI-Watershed Watch & volunteers	See below	See Below	See below		See below
	Expand capacity to address unassessed lakes	URI-Watershed Watch	0	0	No expenses until after 2007		
Establish fish tissue program	Target 10 lakes and ponds	DEM-OWR	0	0	\$50,000	\$25,000 ^u	\$25,000
Freshwater Fisheries Programs –	Largemouth Bass, American Sahd	DEM-F&W	\$200,000	\$200,000	\$216,000	\$216,000	0
Subtotal – lakes			\$200,000	\$200,000	\$266,000	\$241,000	\$25,000

Programs Addressing both Fresh and Marine Waters							
Bathing Beach Program-	Maintain program and expand risk-based approach to freshwaters	HEALTH	\$214,000 ^r	\$214,000	\$317,000 ^v	\$214,000	\$100,000 ^v
URI – Watershed Watch Program	Continue coordination of volunteer-based monitoring	URI	\$192,000 ^t	+/- \$210,000 ^u	+/- \$231,000	\$231,000(w)	\$80,000 (w)
Subtotal – Other Programs			\$406,000	\$424,000	\$548,000	\$368,000	\$180,000
Total – Monitoring Field Programs			\$3,485,000	\$3,606,000	\$5,473,450	\$3,487,467	\$1,985,983

- a) Consists of \$68,000 in NBC costs to maintain two stations; and \$426,500 in federal funds for DEM to purchase new equipment & bring total network stations to 9 stations (3 FTEs & seasonals . DEM Federal funds sources: 2004 Bay Window, NBNERR NOAA grant, EPA PPGs (+/- \$66,500).
- b) Consists of \$70,000 in NBC costs; remainder in federal funds. Three FTEs, seasonals and operating funds for DEM ; with expansion of total network to 13 stations. Does not include costs for replacing NBC station damaged in 2004. DEM federal funding: 2004 & 2005 Bay Window, NBNERR NOAA grant, EPA PPG fund, URI-GSO (grant funds). (RWU not included.)
- c) Consists of \$72,000 for NBC; DEM - three FTEs, seasonals, operating funds and expansion of two stations, purchase of a boat. DEM federal secured funds – portion of 2005 Bay Window grant, NBNERR- NOAA grant - \$70,000.
- d) NBC- \$72,000; DEM/NBNERR- \$70,000 & DEM 2005 Bay Window - \$75,000 & EPA-PPG -\$30,000.
- e) DEM is currently projecting insufficient funds to operate its portion of the existing network (7 of 13 stations without planned expansion) beyond 12/06.
- f) Costs for DEM/NBEP staff time, seasonal support, equipment, operating expenses and data processing for surveys with 3 boats..
- g) NBEP funds and portion of URI FY2005 Bay Window Grant.
- h) DEM - One FTE, seasonals, laboratory, operating and equipment costs.
- i) DEM -2.5 state-funded FTEs. Staff also perform shoreline surveys and other duties within the Shellfish Growing Area Program.
- j) Costs also include monitoring mouths of five major tributaries to Providence River.
- k) DEM -OSPAR Funds.
- l) DEM - Contractual funds to support agreement with USGS. Includes \$15,000 in equipment/capital costs to establish one new station. With adequate notice of availability of state funds, USGS has indicated it may be able to contribute a cost-share of federal funds currently estimated at \$30,000, subject to continued availability.
- m) DEM anticipates this work would be conducted by the biologist to be retained/hired under the rotating basin approach.
- n) DEM - EPA PPG funds (2004-2005). Contractual arrangements (URI, biological services) would be adjusted as staff capacity is built within DEM (rotating basins approach). .
- o) Three FTEs, operating and laboratory costs; One FTE would serve as monitoring coordinator for DEM-OWR.
- p) DEM- EPA funds – 2005/2006;
- q) DEM- EPA funds -2005 PPG funds;
- r) Expanded to incorporate enterococci
- s) Includes \$75,000 in state funding from the WRB, \$55,000 in funding from DEM-OWR. USGS contribution not reflected.
- t) Contractual funds to add and maintain five new stream flow gages via USGS.
- u) DEM EPA PPG funds.
- v) Federal funds provided by BEACH Act. Current funds will expire 9/30/06. Shortfall assumes continued availability of federal BEACH Act funds. If funds are not re-authorized, then the shortfall will climb to \$314,000.
- w) Of this amount, approximately 60% of current funding is derived from USDA and RI Seagrass; 25% from RIDEM grant (federal funding); and 15% from local sponsoring organizations.
- x) The number of waterbodies actively monitored each year may vary. Local sponsors typically inform URI-WW of their intended participation by the spring in advance of the sampling season. The URI-WW Program currently does not receive any state funding to support its direct operations and relies largely on annual grants. Base funding of \$80,000-\$100,000 from the state would provide needed stability to the program.

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Appendix A. State Water Resource Priority Data Needs

Agency/Organization & Program	Current Scope of Program	Water Quality Data Needs
<i>Water Quality Protection & Restoration</i>		
DEM-OWR Surface Water Quality Standards & Criteria	Physical, chemical and biological standards applicable to both freshwaters and saltwaters; updated every three years;	<ul style="list-style-type: none"> • Uses data to refine water quality standards and criteria; • Uses data to evaluate reference conditions; • Needs additional data to develop nutrient criteria; • Needs data to assist in developing tiered designated uses for surface waters.
DEM-OWR Assessment of Surface Water Quality Conditions – 305(b)	Applicable to all surface waters	<ul style="list-style-type: none"> • Compiles data to determine if designated uses of surface waters are being supported; • Need data to develop reference condition for biological data; • Need data to develop indices of biological condition.
DEM-OWR List of Impaired Waters – 303(d)	130 waterbodies listed (2002) 137 waterbodies listed (2004 – DRAFT)	<ul style="list-style-type: none"> • Data used in assessment process identifies which waters are impaired for one or more designated uses; • Data is used to assist in prioritizing waterbodies for TMDL development.
DEM-OWR Water Quality Restoration Plans- also known as TMDLs	15 TMDLs completed; 37 TMDLs pending/under development (As of 8/04)	<ul style="list-style-type: none"> • Uses baseline data in planning targeted water quality studies; • Uses data to isolate specific sources of pollution; • May use flow data, current data, baseline data etc. to support model development where applicable; • Uses data to assess effectiveness of TMDL implementation.
DEM-OWR Reporting on Water Quality Conditions	Integrated Report – 305(b)/303(d)	<ul style="list-style-type: none"> • Data needed to fulfill EPA reporting requirements (Integrated Report) • Data needed to communicate with policy-makers and public • Data needed to support use of environmental indicators • Need data to measure trends in water quality conditions
NBEP Reporting on Conditions in Narragansett Bay		<ul style="list-style-type: none"> • Status and trends report.
DEM-OWR RIPDES Wastewater Permitting	25 Major WWTF permits 87 minor WWTF permits 35 general permittees	<ul style="list-style-type: none"> • Uses water quality and flow data from receiving waters (rivers, coastal waters) to establish level of protection & permit limits; may be used to support modeling. • Uses effluent data to monitor compliance. • Uses data to develop nutrient reduction strategies. <p>Data used to develop CSO abatement strategy.</p>
DEM-OWR RIPDES – wastewater operation & maintenance	25 major WWTFs & selected minor permits	<ul style="list-style-type: none"> • Uses data to evaluate routine WWTF operations. • Use data to evaluate effectiveness of WWTF upgrades. • Data used to measure progress in CSO abatement.
DEM-OWR RIPDES - industrial pretreatment	15 approved local pretreatment programs	<ul style="list-style-type: none"> • Uses data to assess compliance with controls on discharge of toxics
DEM-OWR RIPDES – Stormwater		<ul style="list-style-type: none"> • Uses data on existing impairments in reviewing adequacy of control measures. • Data supports refinement of local stormwater management plans.
DEM-OWR Water Quality Certifications		<ul style="list-style-type: none"> • Uses data in evaluating compliance with anti-degradation policies.
DEM-OWR Shellfish Management	17 growing areas 303 sampling stations; 2,000 samples /year	<ul style="list-style-type: none"> • Collects and uses pathogen data to manage shellfish growing areas. • Collects plankton samples to screen for toxic species.
DEM-OWR		<ul style="list-style-type: none"> • uses data to assess whether non-point sources are being

Agency/Organization & Program	Current Scope of Program	Water Quality Data Needs
Non-point Source Program		<ul style="list-style-type: none"> effectively abated; Uses data to evaluate effectiveness of specific best management practices (BMPs), i.e. stormwater control structure. Uses assessment information in prioritizing funding assistance
DEM Compliance – Water –related Complaints		<ul style="list-style-type: none"> Uses data to understand background conditions. Use data in course of investigations and to support enforcement actions.
DEM Emergency Response – Oil and Chemical Spills, Fish kills etc.		<ul style="list-style-type: none"> Uses data to assess environmental impacts and natural resource damages; Uses data to establish background conditions in some circumstances.
WRB Water Allocation	Management policies under development	<ul style="list-style-type: none"> Use flow monitoring and measurements of groundwater elevations; Use basin water budgets to develop policies
WRB Water Supply System Management	Monitor and manage	<ul style="list-style-type: none"> Use supply and demand management for strategic planning and coordination with RIEMC
WRB Drought Management	Monitor and manage	<ul style="list-style-type: none"> Monitor National Weather Service & USGS surface/water Conditions data; Use flow and groundwater elevation data as triggers for actions in the statewide drought management plan.
Watershed Protection Planning Initiatives		<ul style="list-style-type: none"> Use data to prioritize protection actions
<i>Public Health Protection</i>		
HEALTH Drinking Water Protection	42 public drinking water reservoirs Public and private wells	<ul style="list-style-type: none"> Collects and uses data to monitor safety of public drinking water supplies Uses private well data.
HEALTH Public Bathing Beaches	118 public beaches	<ul style="list-style-type: none"> Collects data to monitor pathogens at bathing beaches. Uses data to close beaches due to water quality degradation. Data needed to identify pollution sources and devise abatement strategies
HEALTH Environmental Health Risk Assessment		<ul style="list-style-type: none"> Issues fish consumption advisories based on fish tissue data and other information.
<i>Waste Management</i>		
DEM-OWM Site Remediation programs		<ul style="list-style-type: none"> Uses data in characterizing extent of contamination. Uses data to establish or assess background conditions in urban areas. Uses data to establish remediation goals. Uses data in risk assessments. Uses data to resolve natural resource damage claims.
<i>Fisheries Management/Habitat Restoration</i>		
DEM-F&W Freshwater Fisheries	Statewide - freshwaters	<ul style="list-style-type: none"> Uses water quality data in interpreting fish population data. Uses fish population data to evaluate ...
DEM-F&W Marine Fisheries	Coastal waters	<ul style="list-style-type: none"> Uses temperature and other data in evaluating depletion of fish stocks. Uses fish population data to manage fish stocks.
Marine Invasive Species	Coastal waters	<ul style="list-style-type: none"> Use data to determine the presence and extent of bioinvasives in coastal waters.

Appendix B.

Table B-1. Federal Requirements Applicable to State Water Monitoring Programs

State Program	Applicable Federal Requirements	Description
State Water Quality Standards and Assessment	<u>EPA Elements of a State Water Monitoring and Assessment Program</u> CALM Guidance 40 CFR Part 35.168(a)	Describes requirements for complying with provisions of the federal Clean Water Act
Environmental Monitoring – Quality Management Plan (DEM)	<u>EPA Requirements for Quality Management Plan (QA/R-2)- grant condition</u> <u>EPA Requirements for Quality Assurance Project Plans (QA/R-5)</u> <u>Guidance on Quality Assurance Project Plans (QA/G-5)</u>	DEM operates with an approved QMP required by EPA. All monitoring supported by federal EPA funds must be done in accordance with EPA approved QAPPs. See section 7.0 for more detail.
Shellfish Growing Area Management Program (DEM-OWR)	Interstate Shellfish Compact administered by FDA	FDA specifies minimum requirements that affect sampling locations, frequency, data analysis etc.
RI Pollution Discharge Elimination System (RIPDES) (DEM-OWR)	Federal rules and guidance	EPA rules dictate minimum effluent sampling requirements for wastewater dischargers; enforced via DEM rules; requires participation in PCS data management system
Non-point Source Pollution Program (DEM-OWR)	EPA program guidance	Results in monitoring to measure or support estimates of reductions in pollutant loadings; required participation in GRITS reporting database system
TMDLs (DEM- OWR)	EPA policy	Policies regarding the approval of TMDLs influence the sampling designs developed in this program
Narragansett Bay Estuary Program	<u>Monitoring Guidance for the National Estuary Program (EPA 842-B-92-004)</u>	
Fixed-Site Monitoring - NBNERR	NOAA Program guidance and grant conditions	NOAA National Estuary Reserve System issues standard operating procedures and guidance that covers water monitoring and data management activities
Beach Monitoring – HEALTH	<u>EPA National beach Guidance and Required Performance Criteria for Grants</u>	Specifies various requirements for implementing beach monitoring; e.g. methods, parameters, etc.
Public Drinking Water Supplies HEALTH	Safe Drinking Water Act – rules and guidance	EPA specifies minimum requirements for monitoring drinking water supplies; enforced via HEALTH rules
Finfish surveys – Marine	Complies with standards and methods set by USF&W, NMFS, and ASMFC (dependent on funding source)	Conducted using accepted scientific techniques/peer reviewed

Appendix C.

Table C-1. State Agency Involvement in Water Monitoring Programs

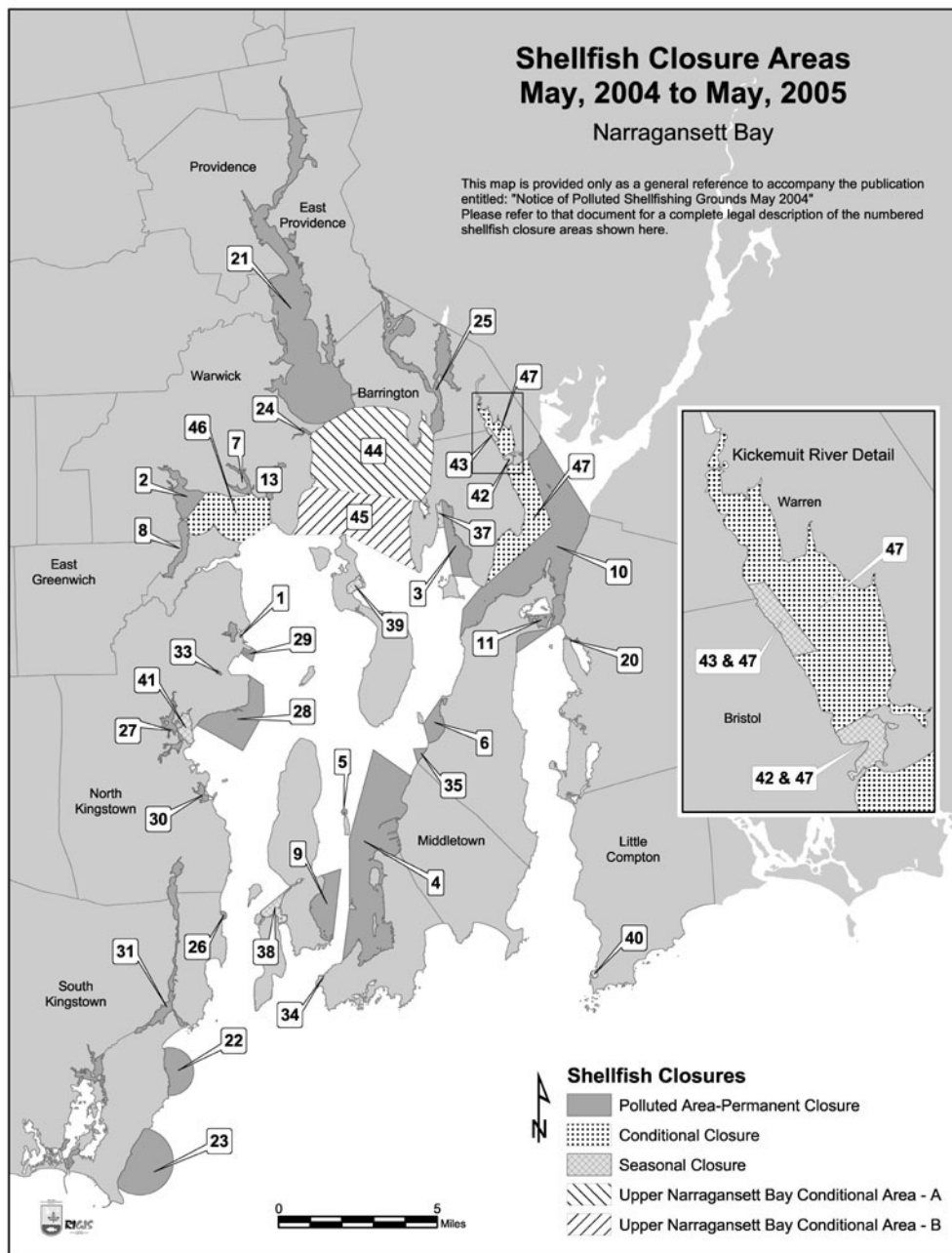
Agency	Monitoring Program
Baseline Programs – Water Quality & Quantity	
DEM-OWR	Baseline water chemistry in rivers – Agreement with URI – 25 stations sampled quarterly; sampling design revised to reflect rotating basin approach in spring 2004
DEM-OWR	Baseline biological monitoring – DEM contractor (ESS) – once per year at 45 stations;
DEM-OWR	Baseline water quality monitoring – large rivers- via agreement with USGS – 7 stations; <i>suspended 10/02.</i>
DEM-OWR	Baseline biological monitoring of large rivers – artificial substrates; 7 stations- <i>suspended in 2003 due to staff vacancy.</i>
DEM-OWR	Baseline monitoring of lakes – agreement with URI-Watershed Watch
DEM-OWR	Bacteriological Monitoring of Shellfish Growing Areas – 303 stations
DEM-OWR	Biotoxin Shellfish Poisoning (with DOH)
DEM-OWR	Groundwater Level measurements (including agreement with USGS)
Multi-agency	Fixed Site Continuous Monitoring Network – Narragansett Bay
Multi-agency	Narragansett Bay Dissolved oxygen surveys with volunteers – 1999-2003; Replaced with targeted surveys for 2004 (NBEP & DEM)
NBC	Baseline water chemistry in selected rivers : Ten Mile, Seekonk, Providence -2000 to present
NBC	Regional River Fecal Coliform monitoring: 21 stations on Moshassuck, Blackstone, Woonasquatucket, West and Providence Rivers; 1998 to present
DEM-OWR & WRB	Stream Flow gaging stations – 16 locations per agreement with USGS
WRB	Basin Studies – via agreement with USGS; water availability
WRB	Major Water Supply Systems - Supply and Demand Inventory
Baseline Programs - Fisheries Management – Marine & Anadromous	
DEM-F&W	Marine Fisheries – finfish populations (trawl)
DEM-F&W	Marine Fisheries – juvenile finfish populations
DEM-F&W	Marine fisheries – finfish in coastal ponds
DEM-F&W	Adult American Shad and River Herring Monitoring
DEM-F&W	Juvenile American Shad and River Herring
DEM-F&W	Pelagic gamefish survey (gill nets)
DEM-F&W	Lobster Fishery Monitoring – size, sex, color, status
DEM-F&W	Shellfish population monitoring
DEM-F&W	Shellfish disease survey
DEM-F&W	Horseshoe crab survey
DEM-F&W	Winter flounder survey
DEM-F&W	Juvenile eel survey
DEM F&W	Ichthyoplankton survey
NBEP	SAV surveys
NBEP/CRMC	Invasive species in marine waters
Baseline Programs - Fisheries Management – Freshwaters	
DEM-F&W	Freshwater fish surveys- largemouth bass
	Pond and Stream fish surveys – statewide
Public Health Programs	
HEALTH – OFP	Bathing Beach Monitoring including investigation of pollution sources causing beach closures
HEALTH - DWQ	Public Drinking Water Supply
Water Pollution Control Programs	
DEM-OWR	WWTF Effluent Monitoring- Priority Pollutants (major dischargers including NBC)
DEM-OWR	WWTF Effluent Monitoring – Compliance with RIPDES (dischargers including NBC)
DEM-OWR	TMDL Water Quality Studies – targeted to specific waterbodies
DEM-OWR	Other Permit Oversight – required monitoring: UIC, water quality certification, etc. (varies)
DEM-OCI	Water pollution complaint investigations – site specific; includes assistance on beach closure investigations
Waste Management Pollution Control Programs*	
DEM-OWM	Site Assessments and Site remediation monitoring – LUST, RCRA, CERCLA, Brownsfields, State sites - site specific
DEM-OCI	Waste –related complaint investigations
Emergency Response*	
DEM	Site specific monitoring. Assessment of natural resource damage claims following major spill events.

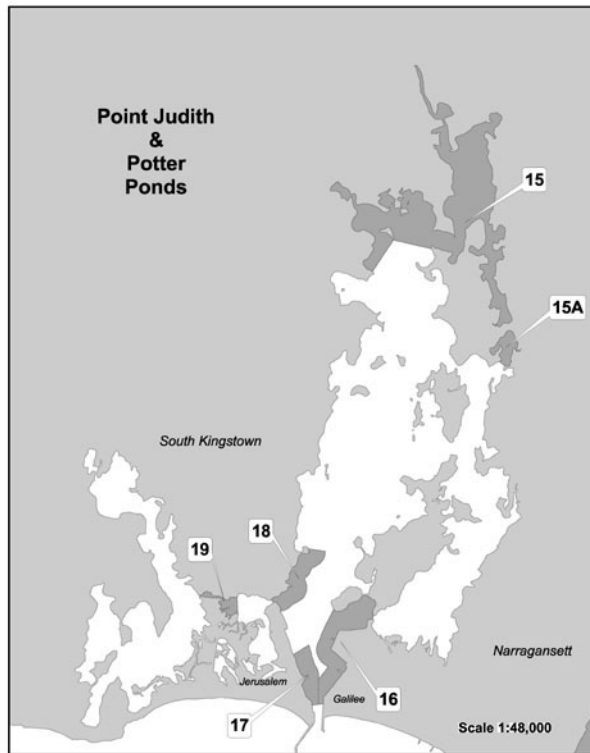
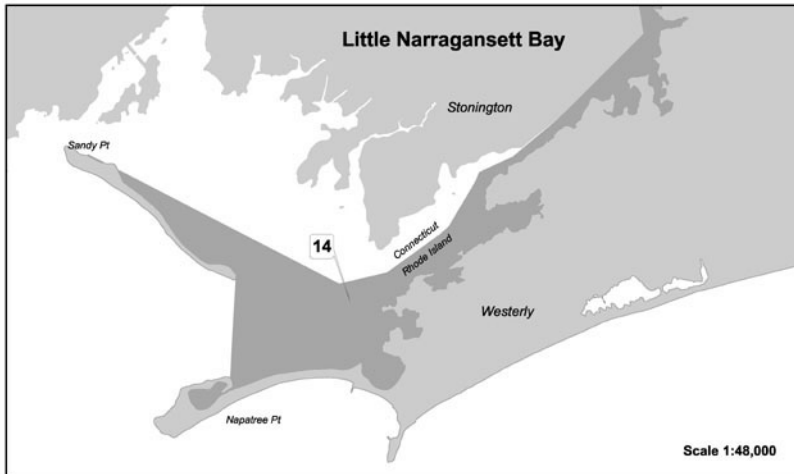
* These programs are not primarily focused on surface water resources but are known to be involved with water quality monitoring and generate data.

Appendix D.

Table D-1. Selected Research Programs Conducting Monitoring in Narragansett Bay

Research Program/Project	Agency/Contact	Data Collection Period
Aircraft Remote-Sensing for Chlorophyll-a	EPA-AED /Darryl Keith	
Amphipod Population Study	EPA-AED/ Ann Kuhn-Hines	1996-2000
Lobster Tagging Program/ URI-Fisheries Center	URI- Fisheries Center/ Kathleen Castro	1994-
National Status and Trends Program/NOAA	NOAA /Tom O'Connor	1984- present
Restoration Center Programs/NOAA	NOAA-NMFS/ Jim Turek	2000-present
Monthly Trawls – Bay Window	NOAA-NMFS/ Dr. Mark Berman (Bay Window Funding)	1998 – present
Ctenophore Abundance & Distribution	URI -GSO/Dr. Barbara Sullivan, (RI Sea Grant Funding)	June 1999 - 2004
Assessment of Saltmarsh Communities	Brown U./ Dr. Mark Bertness (RI Sea Grant Funding)	1997-2002
Lobster Laval Settlement Index	Bigelow Laboratory, ME/ Dr. Richard Wahle,	1990-on-going
Lobster Shell Disease Program	URI/CMER/ Kathleen Castro (RI Sea Grant Funding)	1997-2001
National Coastal Assessment /EMAP	EPA-AED/ Dr. Hal Walker	2000- present
Benthic Fauna in Narragansett Bay	URI-GSO /Dr. Candace Oviatt	1999-present
Water Column Nutrients	URI-GSO/ Dr. Candace Oviatt	1976- present
Phytoplankton in Narragansett Bay	URI-GSO/ Dr. Paul Hargraves/ Dr. T.J. Smayda	1950s- present; some gaps
Finfish Surveys – Bottom Trawl	URI-GSO	1959 - present
Quonochontaug Pond Fellowship – water pollution, circulation & habitat	URI-GSO/ Kathryn Ford,	1999- present





Shellfish Closure Areas May, 2004 to May, 2005

Little Narragansett Bay

Point Judith Pond
Potter Pond

Warning:
This map is provided only as a general reference
to accompany the publication entitled:
"Notice of Polluted Shellfishing Grounds May 2004"
Please refer to that document for a complete legal
description of the numbered shellfish closure areas
shown here.

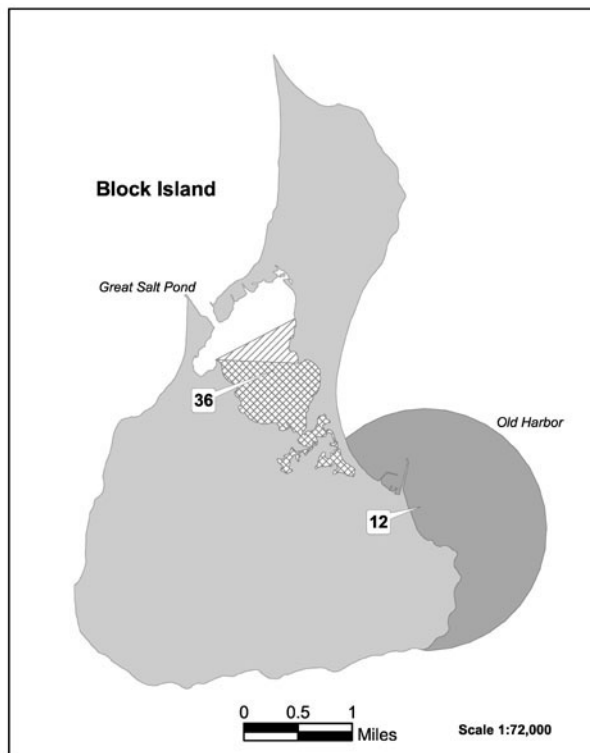
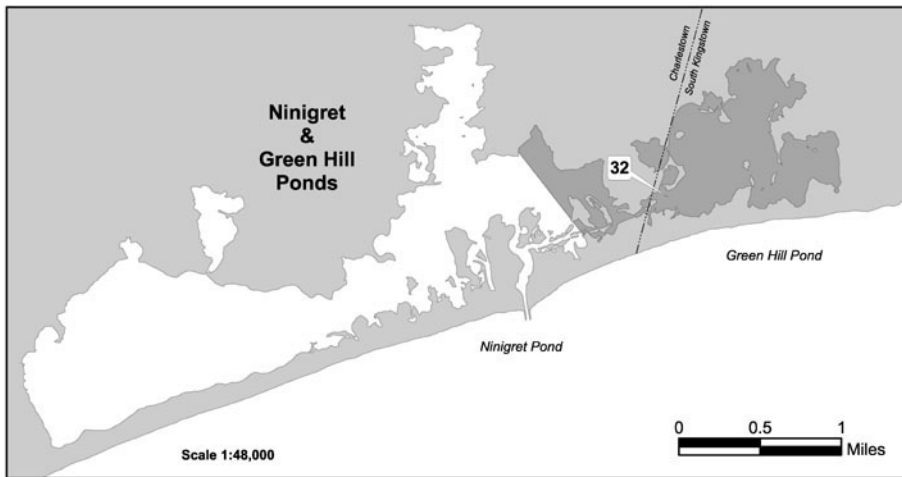
Shellfish Closures

■ Polluted Area-Permanent Closure



0 0.5 1
Miles





Shellfish Closure Areas May, 2004 to May, 2005

Ninigret & Green Hill Ponds

Block Island

This map is provided only as a general reference to accompany the publication entitled: "Notice of Polluted Shellfishing Grounds May 2004". Please refer to that document for a complete legal description of the numbered shellfish closure areas shown here.

Shellfish Closures

-  Block Island Seasonal Closure A & C
-  Block Island Seasonal Closure B
-  Polluted Area-Permanent Closure



Appendix F

Table 6 was developed to aid in evaluating how each of the designs considered by DEM as options for monitoring rivers and streams support the state's water quality management programs. For further discussion, refer to MBI, 2003.

Table 6
Relative degrees to which major water quality management program areas are supported by different spatial and temporal monitoring designs.

Design	Basic Reporting		WQS Program					Watersheds/ NPS		TMDL/303d		NPDES/Other Permitting							
	Status ²	Trend ³	Tiered Uses ⁴	UAA ⁵	Refined WQC ⁶	Anti-deg.	Site-Specific Crit. Mod. ⁷	NPS/BMP Effectiveness	Habitat ⁸	List/Delist	TMDL Dev. ⁹	WQ BELs ¹⁰	Priority Setting ¹¹	CSOs/ SSOs	Storm-water Ph. I&II	WET Limits/ Cond. ¹²	Severity/ Extent ¹³	Enforcement ¹⁴	404/401 Dredge & Fill ¹⁵
Fixed Station	○	○	—	—	—	—	—	○	○	—	○	○	—	○	—	—	—	—	—
Synoptic Watershed	◐	◐	○	○	○	○	○	○	○	○	○	○	○	—	—	—	—	—	—
Intensive Survey	◐	◐	●	●	●	●	●	●	●	●	●	●	◐	●	●	●	●	●	●
Probabilistic: Regional	◐	◐	—	—	◐	—	—	◐	◐	○	—	—	—	—	—	—	◐	○	—
Probabilistic: Watershed	●	●	◐	○	◐	◐	○	●	◐	◐	◐	○	◐	◐	◐	—	◐	○	—
Geometric Watershed	●	●	●	●	●	●	◐	●	●	●	●	◐	●	●	●	◐	●	●	●

- - Comprehensively fulfills program support role by providing robust and complete assessment of program needs and issues including scientific certainty and accuracy of condition assessment.
- ◐ - Generally fulfills program support, but may not provide sufficiently robust or accurate assessment information at all scales or for overall assessment of magnitude and severity.
- - Supports only partial or indirect assessment of program area, e.g., may be useful only for pollutant-specific assessment at a single scale.
- Cannot support program needs due to incomplete spatial coverage, connectivity, or inadequate resolution at the equivalent scale of management.

¹ Design types are inherently generic; modified and hybrid approaches are possible and will encounter the attributes and characteristics of each generic design.

² Basic attainment/non-attainment assessment for aquatic life use status including delineation of causes and sources of threat and impairment.

³ Sufficient information to report aggregate status within specific ecotypes over at least a 10 year period including all sources and causes of impairment at all relevant scales of management.

⁴ Tiered uses that are developed based on assemblage assessments and which correspond to EPA's biological condition axis; does not include generic fishery based or general uses.

⁵ Includes any use of ambient monitoring data to change designated uses on a site-specific or waterbody specific scale.

⁶ Design results in the aggregate accumulation of data that is used to influence the application or implementation of WQC (exclusive of pH, hardness, and other single parameter modifiers).

⁷ Yields sufficiently detailed ambient data that is used to ground truth EPA's site specific criteria process (water effects ratio).

⁸ Monitoring design is sufficient to assess habitat at both local, reach, and watershed scales and develop habitat relationships with biological condition to support tiered use implementation.

⁹ Includes using ambient data to support TMDL development and determine success of TMDL implementation beyond basic calibration data.

¹⁰ Water quality based effluent limits – reach-specific monitoring data is used to develop an assessment of the overall effect of the subject discharge on the receiving waters.

¹¹ Ambient monitoring data is used to influence priority setting for various water quality management program needs (e.g., NPDES permitting and/or SRF funding priorities) at all relevant scales.

¹² Ambient monitoring data is sufficiently detailed to influence WET testing requirements and/or effluent limits in NPDES permits.

¹³ Monitoring design and assessment framework allows for determination of incremental departures and changes beyond pass/fail and communicates severity of problem over space & time.

¹⁴ Monitoring design supports site-specific and/or case specific enforcement in terms of demonstrating that the action is both legal and reasonable.

¹⁵ Direct support of site-specific decisions for the 401 certification of 404 dredge and fill permits.

Appendix G

STREAM SAMPLING SITES FOR 1992 - 2001
BIOLOGICAL AND CHEMICAL BASELINE MONITORING

STREAM	TOWN	SAMPLING LOCATION	BIOLOGICAL MONITORING	CHEMICAL MONITORING
Abbot Run Brook (No)	Cumberland	Route 120	1992 - 2001	'91,'93,'96-'01
Abbot Run Brook (So)	No. Attleboro	Valley Rd.	1992 - 2001	'91,'93,'96-'01
Adamsville Brook	Adamsville	At USGS gage on Rt. 81 (Crandall Rd)	1992 - 2001	1991
Ashaway River	Hopkinton	At Rt. 216 below bridge	1992 - 2001	'91,'93,'96-'01
Bailey's Brook	Middletown	Kempenaar's Clambake (private rd)	1992 - 2001	'91,'93,'96-'01
Beaver River	Richmond	Shannock Hill Rd.	1992 - 2001	'91,'93,'96-'01
Big River	W. Greenwich	South side of Rt 3	1992 - 2001	'91,'93,'96-'01
Blackstone River	Lincoln	Below Manville Dam	1992 - 2001	-
Buckeye Brook	Warwick	Rt 117A at Lockwood Corner	1992 - 2001	-
Bucks Horn Brook	Coventry	At Lewis Farm Rd	1992 - 2001	'91,'93,'96-'01
Canonchet Brook	Hopkinton	Woodville\Alton Rd	1992 - 2001	'91,'93,'96-'01
Carr River	W. Greenwich	Burnt Saw Mill Rd	1992 - 2001	-
Chipuxet River	Exeter	Wolf Rocks Rd	1992 - 2001	'91,'93,'96-'01
Clear River	Burrillville	Victory Highway	1992 - 2001	'91,'93,'96-'01
Cold Brook	Little Compton	Pottersville Road	1992 - 2001	1991
Congdon Brook	W. Greenwich	At south side of bridge near old foundation	1992 - 2001	-
Dolly Cole Brook	Foster	Old Danielson Pike	1992 - 2001	-
Dundery Brook	Little Compton	Swamp Road	1992 - 2001	'91,'93,'96-'01
Fall River	Exeter	North of Route 165	1992 - 2001	'91,'93,'96-'01
Hardig Brook	Warwick	Toll Gate Rd near Little Gorton Pd	1992 - 2001	'93,'96-'01
Hemlock Brook	Foster	150 m W of Hemlock Rd bridge	1992 - 1995	-
Hunt River	E. Greenwich	Route 1	1992 - 2001	'91,'93,'96-'01
Jamestown Brook	Jamestown	Watson Farm Road	1992 - 1998, 2001	'91,'93,'96-'01
Keech Brook	Burrillville	At covered bridge in Geo. Washington Mgmt. Area	1992 - 2001	'91,'93,'96-'01
Kickamuit River	Swansea, MA	At Poverty Corner Road	1993 - 2001	-
Lawton Valley Brook	Portsmouth	Below Newport Res. Off Rt 114	1993 - 2001	-
Maidford River	Middletown	Prospect Avenue	1992 - 2001	'91,'93,'96-'01
Maskerchugg River	E. Greenwich	Route 1 before Goddard Park	-	'91,'93,'96-'01
Meadow Brook	Richmond	Pine Hill Rd (Carolina Management Area)	1992 - 2001	'91,'93,'96-'01
Moosup River	Coventry	At Rt 14 Bridge	1995 - 2001	-
Moswansicut Brook	Scituate	Near Rt. 116, west 80 m - below old stone bridge	1992 - 1995	-
Nipmuc River	Burrillville	South of Brook Road - Top Brk. Below pool	1992 - 2001	-
Nooseneck River	W. Greenwich	West side of Rt 3	1992 - 2001	-
Palmer River	Rehoboth, MA	At County Street	1995 - 1998	-
Parris Brook	Exeter	Blitzkreig Trail	1992 - 2001	'91,'93,'96-'01
Pascoag River	Burrillville	Grove St. bridge	1992 - 2001	'91,'93,'96-'01
Pawcatuck River	Westerly	Below White Rock Bridge	1993 - 2001	-
Pawtuxet River	Cranston	At USGS gage in Cranston	1992 - 2001	-
Queens River	Exeter	Liberty Road	1992 - 2001	'91,'93,'96-'01
Round Top Brook	Burrillville	Brook Road	1992 - 1993	'91,'93,'96-'01

STREAM	TOWN	SAMPLING LOCATION	BIOLOGICAL MONITORING	CHEMICAL MONITORING
Runnins River	Seekonk	At Rt 44 bridge	1993, 1995 - 2001	-
Rush Brook	Scituate	100 m W of Elmdale Bk	1992 - 1995	-
Saugatucket River	Wakefield	Rt 1A bridge	1992 - 2001	-
Silver Creek	Bristol	At Chestnut Street	1993 - 2001	-
Swamp Brook	Scituate	15 m NW of inflow pt. of Ponaganset Rv. into Scituate Res.	1992 - 1995	-
Ten Mile River	E. Providence	Broadway Bridge	1992 - 1998, 2001	-
Tomaquag Brook	Hopkinton	Chase Hill Rd	1992 - 2001	'91,'93,'96-'01
Wilbur Hollow Brook	Scituate	3 m N of culvert crossing on Old Plainfield Pike	1992 - 1995	-
Wood River	Richmond	North of Skunk Hill Rd off Old Nooseneck Road	1992 - 2001	'91,'93,'96-'01
Woonasquatucket River	Providence	Eagle Street Bridge	1992 - 2001	-

Partitioning of State into Watershed Assessment Units

Target size of sub-basin: 100 – 200 mi²

Target size of major river basins: 200-300 mi² with reaches of 30-50 miles

In watersheds overlapping the state boundary, the area and river miles listed below are calculated for the portion of the watershed that lies within Rhode Island.

<u>Watershed Assessment Unit</u>	<u>Area mi²</u>	<u>River miles</u>
1. Blackstone River HUC 8	232	209
2. Pawcatuck River HUC 10	232	342
3. Cape Cod HUC 8	67	41
<u>Quinebaug HUC 8</u>	<u>203</u>	<u>107</u>
Border Areas	270	148
4. Narragansett Bay HUC 10	225	213
5. Ten Mile River HUC 10	56	7
Woonasquatucket &		
Moshassuck Rivers HUC 10	75	115
Palmer River HUC 10	68	17
<u>Lower Taunton River HUC 10</u>	<u>30</u>	<u>5</u>
Urban Rivers	229	144
6. Upper Pawcatuck River HUC 10	153	202
<u>Lower Pawcatuck River HUC 10</u>	<u>44</u>	<u>23</u>
Pawcatuck River	197	225
7. Wood River HUC 10	90	103
<u>Southwest Coastal Ponds HUC 10</u>	<u>82</u>	<u>62</u>
Wood River/ Southwest Coastal Ponds	172	165

Appendix I Stream Gages
 Prioritization of Stream Gages for a Stream Gaging Network in Rhode Island

Priority	Watershed Location 12-digit HUC Name	Gage Status	Gage #	Potential Site Location	Existing Funding Source
E	Beaver River	Perm.	01117468	Beaver River	WRB
E	Branch River	Perm.	01111500	at Forestdale	RIDEM
E	Blackstone River - West River to Peters	Perm.	01112500	Blackstone @ Woonsocket	Ocean State Power
E	Chipuxet River	Perm.	01117350	Chipuxet River	WRB
E	Clear River	Perm.	01111300	Nipmuc River	RIDEM
E	Hunt River	Perm.	01117000	Hunt River	WRB
E	Millers River	Perm.	01113695	Catamint Brook	RIDEM
E	Moshassuck	Perm.	01114000	Moshassuck River	RIDEM
E	Pawcatuck Mainstem	Perm.	01117500	Wood River Junction	USGS
E	Pawcatuck(Lower)	Perm.	01118500	Westerly	WRB
E	Pawtuxet River Mainstem	Perm.	01116500	Pawtuxet at Cranston	FEMA
E	Pawtuxet River (South Branch)	Perm.	01116000	South Branch - Pawtuxet	WRB
E	Ponnagansett and Barden Reservoirs	Perm.	01115187	Ponnegansett River	RIDEM
E	Queen River	Perm.	01117370	Liberty Lane	RIDEM
E	Regulating and Moswansicut Reservoir	Perm.	01115098	Peeptoad Brook	Providence Water
E	Ten Mile River	Perm.	01109403	Ten Mile River	RIDEM
E	Usquepaug River	Perm.	01117420	Usquepaug	WRB
E	Wood River(Upper)	Perm.	01117800	Arcadia	WRB
E	Wood River (Lower)	Perm.	01118000	Hope Valley	WRB
E	Woonasquatucket	Perm.	01114500	Woonasquatucket River	RIDEM
1	Pawcatuck(Upper)	Project	01117424	Chickasheen River	
1	Pawcatuck(Lower)	Project	01117460	Pawcatuck Mainstem at Kenyon	
2	Beaver River	Project	01117472	Lower Beaver	
2	Hunt River (Upper)	Temp.	01116910	Hunt River	
2	Pawcatuck Mainstem	Project	01118010	Burdickville	
3	Westport	Discont.	01106000	Adamsville Gage	
4	Big River	Project	01115800	Big River	
4	Blackstone River - Peters to Mouth	Project	01113650	Roosevelt Avenue, Pawtucket	
4	Millers River	Temp.	01113760	Abbott Run	
4	Pocassett River	Temp.	01116609	Pocassett Gage	
4	Taunton River	H		Taunton	
5	Ashaway River	Project	01118360	Ashaway Gage	

Priority	Watershed Location 12-digit HUC Name	Gage Status	Gage #	Potential Site Location	Existing Funding Source
5	Saugatucket	Temp.	01117230	Saugatucket River	
5	Mill River	Project	01112382	Mill River	
5	West Passage(Lower)	Temp.	01112382	Annaquatucket below Belleville Pond	
6	Big River	Project	01115630	Nooseneck	
6	Clear River	Temp.	01111267	Maybe move Nipmuc to Clear or add Clear	
6	Chepatchet	Temp.	01111265	Chepatchet River	
6	Pawtuxet (South Branch)	Temp.	01115970	Mishnock River	
6	Pawtuxet (North Branch)	Discont.	01115600	Fiskville	
6	Sakonnet River		A	Borden Brook	
6	Sakonnet River		B	Maidford or Paradise	
7	Big River	Temp.	01115730	Carr River	
7	East Passage (Upper)		D	Lawton Brook	
7	Greenwich Bay	Temp.	01116750	Maskerchugg River	
7	Moosup River (Upper)	Temp.	01126224	Moosup River	
7	RI Sound		C	Dundry Brook	
7	Woonasquatucket	Temp.	01115010	Valley Street or Dyerville	
8	Barrington and Warren Rivers		E	Runnins River	
8	Coastal Aquidneck		G	Bailey Brook	
8	Flat River	Temp.	01115900	Upstream of Reservoir	
8	Mount Hope Bay		F	Kickemuit	
8	Narragansett Bay (Upper)	Temp.	01116635	Buckeye Brook	
8	Pettaquamscutt River	Temp.	01117200	Gilbert Stewart	
8	Scituate	Temp.	01115400	Dam Release	
X	Block Island				
X	East Passage (Lower)				
X	Fivemile River (Lower)				
X	Fivemile River (Upper)				
X	Lower Moosup River				
X	Palmer River				
X	Point Judith Pond				
X	Quaduck Brook				
X	Quequechan River				
X	Seekonk and Providence River				
X	Southwest Coastal Waters				

Priority	Watershed Location 12-digit HUC Name	Gage Status	Gage #	Potential Site Location	Existing Funding Source
X	Upper Pauchaug River				
X	West Passage (Upper)				

Notes:

E = Existing: Existing gages determined to have the highest priority.

X = No stream gaging required since stations are tidal or watershed size within RI is insignificant.

Perm. = Permanent Gage with structure built and monitoring ongoing

Disc. = Discontinued permanent gage with structure yet monitoring has ceased

Project = A temporary gage that has an established rating curve and is currently being monitored for a limited period of time associated with a special project

Temp. = A project gage that was discontinued. There is no structure at this site.